

# Study to support the development of scenarios for EU-wide infrastructure planning and adequacy assessments

---

Study carried out by Artelys for ACER

Final report – August 2025

# Contents

OBJECTIVE OF THE DOCUMENT .....	5
EXECUTIVE SUMMARY .....	6
CONTEXT AND OBJECTIVES .....	6
IDENTIFIED CHALLENGES AND ASSOCIATED RECOMMENDATIONS .....	10
<b>1 TASK 1 – DESCRIPTION AND ASSESSMENT OF THE CURRENT PROCESS FOLLOWED BY ENTSO-E AND ENTSOG TO BUILD SCENARIOS.....</b>	<b>19</b>
1.1 FRAMEWORK DEVELOPMENT.....	22
1.1.1 TYNDP.....	22
1.1.2 ERAA.....	23
1.2 SCENARIOS INPUTS .....	23
1.2.1 INVENTORY OF SCENARIO INPUTS.....	23
1.2.2 INPUT DATA CONSTRUCTION PROCESS .....	25
1.2.3 DESIGN OF A REPLICABLE APPROACH TO VERIFY THE SCENARIO’S COMPLIANCE WITH THE NECPS.....	55
1.2.4 RISK OF CONFLICT OF INTEREST.....	60
1.3 SCENARIOS MODELLING.....	63
1.3.1 DESCRIPTION OF THE MODELLING PROCESS .....	63
1.3.2 TOOLS USED IN TYNDP .....	65
1.3.3 TOOLS USED IN THE ERAA.....	80
1.4 SCENARIOS OUTPUTS AND FINALISATION .....	83
1.4.1 TYNDP’S INVENTORY OUTPUTS .....	84
1.4.2 ERAA’S INVENTORY OUTPUTS.....	85
1.4.3 FINALISATION & PUBLICATION.....	87
<b>2 TASK 2 – CONSTRUCTION OF SCENARIO VARIANTS FOR TYNDP AND CONSTRUCTION OF AN ADDITIONAL SCENARIO FOR ERAA .....</b>	<b>88</b>
2.1 BENCHMARKING OF BEST PRACTICES FOLLOWED IN OTHER SPECIFIC JURISDICTIONS WHEN DEVELOPING SCENARIOS.....	88
2.1.1 BENCHMARK METHODOLOGY.....	88
2.1.2 KEY TAKEAWAYS FROM THE BENCHMARK .....	91
2.2 DESIGN OF AN ADDITIONAL SCENARIO FOR ERAA .....	94
2.2.1 INSIGHTS FROM REPORTS BENCHMARK .....	95
2.2.2 PROJECTION OF THE DEMAND .....	97

2.2.3	PROJECTION OF THE NEWLY INSTALLED CAPACITIES .....	113
2.3	DEVELOPMENT OF LOW-ECONOMY AND HIGH-ECONOMY SCENARIOS FOR TYNDP .....	122
2.3.1	SUGGESTED APPROACH – DEMAND .....	122
2.3.2	SUGGESTED APPROACH – SUPPLY .....	134
2.3.3	COMPARISON OF THE PROPOSED APPROACH TO ENTSO-E AND ENTSOG’ PROPOSED APPROACH FOR THE TYNDP 2026 SCENARIO VARIANTS .....	140
<b>3</b>	<b>TASK 3 - COMPARISON AND RECOMMENDATIONS FOR CONVERGENCE BETWEEN THE SCENARIO DEFINITION IN THE TYNDP AND ERAA.....</b>	<b>143</b>
3.1	SUPPLY .....	144
3.2	DEMAND .....	153
3.3	NETWORK.....	160
3.4	STAKEHOLDER ENGAGEMENT PROCESSES.....	164
3.5	COMPLIANCE WITH EU CLIMATE GOALS .....	165
<b>4</b>	<b>TASK 4 - DEFINITION OF A PROCESS AND METHOD TO FILTER AND VALIDATE SCENARIO INPUTS .....</b>	<b>166</b>
4.1	STEP 1 – SELECTION OF A SET OF SOURCES PROVIDING VALUES FOR EACH INPUT .....	167
4.2	STEP 2 – QUALITY SCREENING AND DEFINITION OF MINIMUM STANDARDS .....	168
4.3	STEP 3 – SCORING AND RANKING OF THE RELEVANT SOURCES .....	169
<b>5</b>	<b>ANNEX.....</b>	<b>170</b>
5.1	LIST OF PUBLIC DOCUMENTS STUDIED .....	170
5.2	QUESTIONNAIRE ASKED TO THE TSOs.....	171
5.2.1	<i>CONTEXT AND OBJECTIVES</i> .....	171
5.2.2	<i>CONTEXT ON YOUR COMPANY</i> .....	172
5.2.3	<i>YOUR NATIONAL NECP</i> .....	173
5.2.4	<i>INPUTS VALIDATION</i> .....	178
5.2.5	<i>SCENARIO RESULTS VALIDATION</i> .....	179
5.2.6	<i>RECOMMENDATIONS</i> .....	179
5.3	ANSWERS COLLECTED TO THE QUESTIONNAIRE SENT TO THE NATIONAL TSOs.....	180

## List of recommendations

Recommendation 1 – Transparency of the construction process of the electricity and hydrogen reference grids .....	29
Recommendation 2 – Lack of detail in the NECPs .....	35
Recommendation 3 – Transparency of the sources used by the TSOs to provide national data .....	37
Recommendation 4 – Update of ERAA and TYNDP scenarios in the absence of new NECPs .....	40
Recommendation 5 – Mismatch between the time-horizon in the NECPs and the needs for TYNDP and ERAA scenario building .....	43
Recommendation 6 – Systematic scrutiny and validation by the NRAs of the input data provided by the TSOs	51
Recommendation 7 – Publication consultation on input data .....	53
Recommendation 8 – In-depth collaboration with the European Commission on the consistency of ERAA and TYNDP scenarios with NECPs .....	57
Recommendation 9 – Frequency of ERAA .....	65
Recommendation 10 – Transparency of the ETM tool .....	66
Recommendation 11 – Use of the ETM tool for the data collection on National Trends demand assumptions .	68
Recommendation 12 – Gap filling methodology .....	73
Recommendation 13 – Transparency of the demand-side flexibility assumptions .....	77
Recommendation 14 – Utilisation of several modelling tools in parallel .....	83
Recommendation 15 – Transparency of ERAA’s modelling results .....	86
Recommendation 16 – Alignment of ERAA and TYNDP data collection timelines .....	145
Recommendation 17 – Voluntary deviations between ERAA and TYNDP input data provided by the TSOs .....	147
Recommendation 18 – Transparency of the Security of Supply loop .....	150
19 – Alignment of electrolyzers modelling between ERAA and TYNDP .....	152
Recommendation 20 – Alignment on annual electricity demand between ERAA and TYNDP .....	155
Recommendation 21 – Alignment on peak electricity demand between ERAA and TYNDP .....	159
Recommendation 22 – Alignment on the number of climate years published between TYNDP scenario building process and TYNDP CBAs .....	160
Recommendation 23 – Alignment on network representation between ERAA and TYNDP .....	161
Recommendation 24 – Alignment on grid assumptions building process between ERAA and TYNDP .....	163
Recommendation 25 – Stakeholder engagement process in ERAA .....	165

---

## Objective of the document

This document corresponds to the Final Report of the “Study to support the development of scenarios for EU-wide infrastructure planning and adequacy assessment”. It has been prepared by Artelys on behalf of ACER in the context of the contract awarded under procedure ACER/2024/MVP/0026.

---

# Executive summary

## Context and objectives

**The decarbonisation of the European economy requires massive investment in energy infrastructure, together with a more efficient use of the existing assets.**

The European Union has set ambitious climate and energy goals aimed at achieving climate neutrality by 2050. Central to this vision is the European Green Deal, which outlines a roadmap for reducing greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. In July 2025, the European Commission has proposed to amend the European Climate Law to introduce an additional legally binding objective to reduce greenhouse gas emissions by 90% by 2040 compared to 1990 levels (with the possibility to rely on international carbon credits).

The EU is also committed to increasing the share of renewable energy, improving energy efficiency, and phasing out fossil fuels. These efforts are supported by regulatory frameworks like the Fit for 55 package and the REPowerEU plan, which also aim to enhance energy security and reduce dependence on energy imports.

Reaching these objectives whilst maintaining security of energy supply and affordability of energy for European consumers and businesses requires massive investments, notably in energy infrastructure (onshore and offshore electricity networks, storage assets, hydrogen pipelines, underground storage and import terminals, CO<sub>2</sub> networks, etc.). A study<sup>1</sup> recently published by the European Commission estimates the need for investments in energy infrastructure to reach more than 100 B€ per year, every year, until 2040.

### **A range of processes and tools inform infrastructure planning**

The European Union has equipped itself with several processes and tools that inform infrastructure planning and adequacy measures (amongst other objectives).

- | **National Energy and Climate Plans (NECPs)** are strategic frameworks that outline how each EU Member State intends to meet the EU's climate and energy targets. Their main objective pursued by the underlying regulation (Governance Regulation (EU) 2018/1999) is to ensure a coordinated approach across the EU in delivering the EU's climate and energy goals, enhance transparency, and to increase investment certainty.
- | The **Ten-Year Network Development Plan (TYNDP)** is a planning instrument formally introduced by the Clean Energy Package (Regulation (EC) No 714/2009 for electricity; Regulation (EC) No 715/2009 for gas). Developed by ENTSO-E and ENTSO-G (and ENNOH in the future), its main purpose is to identify and facilitate investments in the infrastructure needed to support the EU's energy and climate objectives, with a focus on infrastructure projects that

---

<sup>1</sup> [Link](#)

---

have a cross-border impact. The current TEN-E Regulation (EU) 2022/869, updating Regulation (EU) 347/2013, foresees that, within the TYNDP framework, ENTSO-E and ENTSOG jointly develop transition scenarios every second year. Under the TEN-E framework, each ENTSO must also assess the need for further infrastructure development (System Needs study by ENTSO-E; Infrastructure Gap Identification by ENTSOG) and conduct cost-benefit analysis (CBA) of infrastructure projects submitted by project promoters. The outcomes of the CBAs inform the selection of Projects of Common Interest and Projects of Mutual Interest (PCIs and PMIs). Obtaining this label notably accelerates permitting procedure and opens possibility for funding via the Connecting Europe Facility (CEF). ACER plays an important oversight role in the TYNDP framework. As mandated by the recast TEN-E Regulation, ACER publishes Framework Guidelines for TYNDP scenario building guidelines<sup>2</sup> (hereinafter referred to as “ACER TYNDP Scenario Guidelines”), which outline criteria for developing the TYNDP scenarios. Furthermore, ACER provides a formal opinion on all draft publications related to the various elements of the TYNDP cycle (scenarios, infrastructure needs, CBAs).

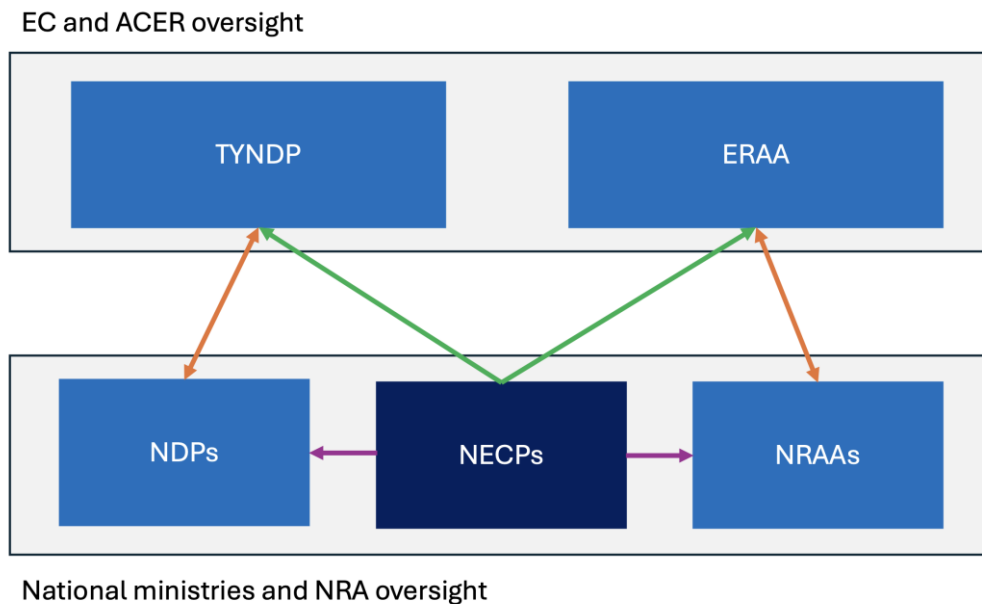
- | The **European Resource Adequacy Assessment (ERAA)** is a pan-European study conducted annually by ENTSO-E, as mandated by the Electricity Regulation (EU) 2019/943. Its main objective is to assess whether the European power system has sufficient resources—such as generation capacity, demand-side response, and interconnections—to reliably meet electricity demand over the coming decade. The ERAA is a key tool informing on the relevance of Member States introducing capacity remuneration mechanisms. It identifies potential adequacy concerns via a probabilistic approach where the resilience of the electricity system is tested for various combinations of climatic conditions and unplanned outages. ACER plays an important role in the ERAA framework. As mandated by the Electricity Regulation, ACER must approve the ERAA methodology and issue each year a formal opinion on the draft ERAA report. In April 2025, ACER requested ENTSO-E to develop a proposal for the amendment of the ERAA methodology, which involves an evolution of the way ERAA scenarios are established.

Additional European-level tools inform on the need for deploying energy infrastructure and technologies but are outside the scope of this study. Amongst these, the **Flexibility Needs Assessment (FNA)** has recently been introduced under the EU Electricity Market Design Reform (EMDR; Regulation (EU) 2024/1747) to support the integration of variable renewable energy sources and ensure grid stability, and to inform the design of support schemes for non-fossil flexibility solutions by Member States. As per Article 19(e) of the EMDR, the FNA should be “consistent with the European resource adequacy assessment and national resource adequacy assessments”. The FNA methodology has been submitted by ENTSO-E and EU DSO Entity to ACER in April 2025, and approved in July 2025. The publication of the first national FNAs is expected in Q3 2026.

---

<sup>2</sup> [Link](#)

In addition to these European-level processes and tools, national instruments are also used by Member States to inform their policy-making initiatives and to support the planning of investments in energy infrastructure. The most relevant type of national instruments vis-à-vis the subject-matter of this study are the national electricity and gas network development plans (NDPs), established by electricity TSOs and gas TSOs, respectively; and the national resource adequacy assessments (NRAAs), established by electricity TSOs. The processes leading to these national publications are not independent from the European processes described above, as they feed into one another, as depicted below. The NECPs inform the scenarios of TYNDP and ERAA (green arrows), and can be used as a basis of national planning processes (e.g., Directive (EU) 2024/1788 mentions that gas and hydrogen NDPs shall be based on scenarios that are in line with TYNDP scenarios and with NECPs, see purple arrows). Finally, the national processes can be used to provide assumptions used in TYNDP and ERAA (complementing the ones coming from the NECPs, see orange arrows), and TYNDP and ERAA can be used as frameworks for national planning and adequacy exercises.



**Figure 1 - Illustration of the links between EU and national instruments (non-exhaustive). NECPs inform TYNDP and ERAA scenarios. NECPs, TYNDP and ERAA scenarios inform national network development plans (NDPs) and adequacy assessments (NRAAs). National documents might also be used by TSOs to fill the gaps w.r.t. NECPs to establish the TYNDP and ERAA scenarios.**

**Consistent scenarios allow for coordinated transition**

Due to their different objectives and purposes, the instruments described above feature important differences. With regards to time horizons, the current set of NECPs focus on 2030 objectives, the most recent TYNDP scenarios (TYNDP 2024) describe transition pathways to 2040 or 2050 (depending on the scenario), and ERAA focuses on the ten years ahead. The level of time resolution, geographical coverage, technology granularity, etc. of the scenarios also vary significantly between NECPs, TYNDP and ERAA.

However, given that the scenarios being used in these different processes are strongly connected to one another, it is important to ensure a basic level of consistency between them. As a result, European legislators, policymakers and regulators have introduced the following connections to ensure a degree

---

of consistency between the scenarios that define energy policies (NECPs), the ones that inform energy infrastructure planning (TYNDP) and the ones that inform security of electricity supply policies (ERAA):

- | **TYNDP:** Article 12(1) of the recast TEN-E Regulation mentions that the TYNDP scenarios should take into account NECPs. The same article mandates ACER with the task of developing ACER TYNDP Scenario Guidelines. These guidelines, published in early 2023, mention that the ENTSO-E and ENTSO-G should consider the NECPs as the basis for the development of a “best estimate” scenario, that should be accompanied by contrasting high- and low-economy variants. The guidelines were only partly applied in TYNDP 2024.<sup>3</sup> EU law also formally requires regulators to monitor the consistency between EU and national NDPs<sup>4</sup>.
- | **ERAA:** Article 3(3) of the ERAA methodology<sup>5</sup> sets out that the central scenario to be used in ERAA should be based on TSO inputs for demand, supply and grid outlooks that are consistent with “national objectives, targets and contributions, and other projections contained in the NECPs [...]”.

Furthermore, as emphasised above, the scenarios used by Member States when carrying out national-level FNAs need to be consistent with ERAA and national resource adequacy assessments.

Although the connections between NECPs, TYNDP and ERAA scenarios have been implemented in the relevant European regulatory documents, their application at national level has been found to be inconsistent. Indeed, this study identifies significant differences in practices at Member State level and inconsistencies between the TYNDP and ERAA scenarios.

Finally, it is important to mention that the TYNDP scenarios developed by the ENTSO-E and ENTSO-G and the ERAA scenario developed by ENTSO-E need to be adapted prior to being used in some of the subsequent processes, as shortly described below.

- | **TYNDP:** As the National Trends scenario is obtained by combining inputs based on NECPs via a bottom-up process, the resulting supply mix is not guaranteed to deliver security of supply. Prior to conducting cost-benefit analyses of electricity infrastructure projects, the scenario undergoes a so-called “SoS loop” that aims at adjusting the installed capacities to ensure a satisfactory level of loss of load expectation is reached<sup>6</sup>. This process is carried out as part of the CBA process, and not in the scenario development process. At the time of writing, the impacts of the SoS loop on installed capacities had not been published by ENTSO-E.
- | **ERAA:** To deliver a robust analysis of security of electricity supply, the level of installed capacities must make economic sense from a plant operator point of view. In other words,

---

<sup>3</sup> The NT+ scenario considers NECPs as its basis, but the high- and low- economy variants will only be produced in the TYNDP 2026 cycle, replacing the Distributed Energy and Global Ambition scenarios.

<sup>4</sup> Article 51(5) of the Electricity Directive (2019/944); Article 48(2) of the Electricity Regulation (2019/943); Articles 26(9) and 60(2) of Regulation (EU) 2024/1879.

<sup>5</sup> [Link](#)

<sup>6</sup> [Link](#)

scenarios should not consider installed capacities that are uneconomic and should be adjusted if additional units were to be economically viable. This adjustment process is called the “Economic Viability Assessment” (EVA), and can result in retirement of, investment in, (de)mothballing of, or extension of the lifetime of units<sup>7</sup>. The security of supply analysis (calculation of loss of load statistics) is carried out post-EVA.

Unless mentioned otherwise, the scenarios that are examined in this study are the ones established during the scenario building process, i.e. without the SoS loop and the EVA being applied.

### Objectives of this study

This study aims at identifying the potential challenges that may emerge in the scenario building phase associated with the requirement to align TYNDP and ERAA scenarios with NECPs, and at providing recommendations on potential avenues to tackle these challenges. To this end, the publicly available documentation related to scenario building methodologies and stakeholder engagement strategies have been reviewed, questionnaires to gas and electricity TSOs and to National Regulatory Authorities has been created and analysed, and a series of interviews with the ENTSO-E and ENTSG, the European Commission, and other stakeholders have been conducted.

## Identified challenges and associated recommendations

The main challenges that have been identified in the study are summarised in the following paragraphs, together with recommendations on potential ways to tackle these challenges.

### Challenge #1 – NECPs are inconsistently translated into scenario-building inputs for the TYNDP and ERAA

The TYNDP and ERAA scenario building processes include the development of scenarios that are to be based on NECPs (the “National Trends” scenario of TYNDP and the “central scenario” of ERAA). As these three planning instruments (TYNDP, ERAA, NECPs) serve different purposes, the level of details in which the scenarios are described, the cycles and frequency of their updates differ from one another (see Challenge #4). This variability is found to affect the ability to consistently translate NECP inputs into TYNDP or ERAA scenarios.

Indeed, currently, the process of translating NECPs into inputs for TYNDP and ERAA scenario building exercises is entirely decentralised: national gas and electricity TSOs are tasked by ENTSO-E and ENTSG to provide assumptions for scenario building based on their NECPs, while also being given some scope to adapt the assumptions based on latest policy and technology cost developments. Given the high

---

<sup>7</sup> [Link](#)

---

level of heterogeneity between NECPs and the relatively limited number of indicators in the analytical section of NECPs that could support the tasks of TSOs, there are (at least) 27 different such “translation” exercises being carried out.

Not only does this constitute a risk of an inconsistent interpretation of the national policy landscape if different countries were to adopt different practices, but it also means that ENTSO-E and ENTSOG cannot easily and materially review all the contributions submitted by TSOs. It is our understanding that the extent of the verifications (e.g. check by ENTSO-E and ENTSOG of figures reported by TSOs versus the ones extracted from NECPs) of recent scenario building processes has been very limited, likely also due to capacity requirements presented by this heterogeneity barrier. Several deviations between TYNDP/ERAA scenarios and the NECPs have been observed and are discussed in this report.

Finally, as the translation exercise is TSO-specific and checks by other parties are limited, the risk of conflict of interest needs to be taken into consideration (i.e., it could be in TSOs’ interest to use a gap-filling procedure that leads to outcomes of TYNDP and/or ERAA that ultimately benefit the TSOs themselves).

Recent scenario building cycles have implemented processes partly addressing some of the challenges mentioned above:

- | For both the ERAA and TYNDP, ENTSO-E provides an app for data collection (PEMMDB-App), which allows to run a set of quality checks (e.g., outliers, missing data);
- | Transparency efforts have been expanded via the publication of extended datasets during the TYNDP and ERAA scenario development processes; and
- | ENTSO-E and ENTSOG now use an online tool called the Energy Transition Model (ETM), which aims to serve as a common and consistent platform for the development of demand projections by electricity and gas TSOs for the TYNDP.

At the same time, our interaction with stakeholders has revealed the existence of calibration issues, notably for the reference year (2019), and difficulties in using the ETM, which raise concerns over its ability to accurately reflect the specificities of Member States. Moreover, current transparency efforts fall short of allowing for stakeholders to easily and sufficiently assess alignment between TSO-developed scenario inputs and the NECPs, and thus, ultimately, the compliance with ACER TYNDP Scenario Guidelines.

---

**Recommendations:**

- | **A validation step should be introduced in the “translation” process between NECPs and TYNDP/ERAA scenario building processes.** Given the heterogeneity of NECPs and the difficulty for a single institution to assess whether TSOs have interpreted and reported the contents of the NECPs in an appropriate way, our recommendation is to introduce systematic quality checks and a formal validation process of submissions by TSOs. Our assessment is that NRAs would be best placed to perform these tasks. This check and validation process would verify compliance with NECPs and evaluate the admissibility of potential deviations recommended by national TSOs (e.g., by verifying that deviations derive from new laws having been adopted and implemented). Furthermore, the authors of this report propose that a single template is defined and used by all TSOs and NRAs for this process, in order to ensure greater transparency of the deviations from the identified NECP input parameters and to enable cooperation.
- | **Guidance and tools for Member States should be developed to enable NECP improvements and consistent reporting by TSOs:** The authors of this report recommend that ENTSO-E and ENTSOG suggest amendments to the contents of Annex I of the Governance Regulation<sup>8</sup>, which is the section of the Regulation that outlines the specific requirements and templates to be used in NECPs. This guidance should provide Member States clear instructions on the expected level of detail required to carry out the TYNDP and ERAA scenario building processes. This guidance should also include sufficient explanation to Member States about the rationale for providing these details, as they might not be currently aware that NECPs are crucial in European infrastructure planning exercises and adequacy assessments. The intent of this recommendation is not only to reinforce transparency, but also to allow all interested stakeholders to easily assess the compliance of TYNDP/ERAA scenarios with the NECPs. Furthermore, the authors of this report recommend that the ACER TYNDP Scenario Guidelines be updated to provide clarity on the way TSOs should report information to ENTSO-E and ENTSOG when the NECPs do not cover all the required time horizons<sup>9</sup> (e.g. 2040 and/or 2050). This guidance could take the form of e.g. methods/parameters to be used for demand and capacity mix projections, commodity prices, etc.
- | **Building on the consultation of TSOs, ENTSO-E and ENTSOG should examine how to ensure the ETM is fit-for-purpose to collect demand projections and their underlying drivers in a consistent way.** Furthermore, efforts in terms of calibration need to be increased to accurately represent the reference year (currently, 2019), based on publicly available datasets. Extending the use of the ETM (or similar tools) to other dimensions of the scenario building process, including the development of the required economy scenario variants, should only materialise when key issues faced by TSOs in using the tool have clearly been identified and properly addressed (either by agreeing on adaptations with the developer of the ETM or by considering alternative data collection processes).

---

<sup>8</sup> [Link](#)

<sup>9</sup> As the 2040 GHG reduction target should soon be agreed upon, it can be expected that the Governance Regulation will be updated to ensure all NECPs cover 2040, which is not currently the case.

---

**Challenge #2 – There is a lack of clarity on the evaluation of NECPs against EU targets**

The regulatory framework for the development of the TYNDP and ERAA scenarios not only require the respective scenarios to take the NECPs into account, but also for the TYNDP to reach the EU energy and climate targets.

As the NECPs are produced in a decentralised way (each Member State producing it independently), there is no guarantee that their aggregation will meet EU targets when considered jointly. As a matter of fact, the European Commission's assessment of the final NECPs, published on 27 May 2025, found that NECPs were broadly in line with the 2030 GHG reduction target (-54% compared to 1990 levels vs a target of -55%) and with the 2030 RES target (41% vs a target of at least 42.5%)<sup>10</sup>. However, NECPs are further from reaching the 2030 energy efficiency (EE) target (8.1% vs a target of 11.7%). Surprisingly, however, the TYNDP 2026 datasets recently submitted by ENTSO-E and ENTSOG for public consultation show a much larger gap for this same target compared to the gap identified in TYNDP 2024, even though the TYNDP 2026 datasets should be based on the final NECPs and not on the draft NECPs like the TYNDP 2024.

To comply with the relevant regulatory texts, the TYNDP scenario building processes need to include (a) a compliance check with respect to EU targets, and (b) a procedure to adapt the scenario obtained by aggregating NECPs, should some of the targets not be reached. For example, in the TYNDP 2024 cycle, ENTSO-E and ENTSOG have determined that the "National Trends" scenario (NT), which is based on NECPs, was not reaching the Union's target. ENTSO-E and ENTSOG have therefore implemented a gap filling methodology<sup>11</sup> ("NT+ Energy Mix Gap Filling Methodology") to ensure that this scenario meets all targets. The above-mentioned gap filling methodology was specific to the nature of the gap that has been observed (discrepancy of the energy efficiency target) and cannot straightforwardly be extended if other objectives were not to be reached by the NECP-based scenario. It should be noted that neither the final NECPs nor the European Commission's assessment of NECPs were available at the time of TYNDP 2024 scenario building.

**Recommendations:**

- | **Align the methodology used to verify EU targets compliance with the European Commission.** Implementing this recommendation requires (a) to compare the NECP figures used by the European Commission in their analysis of NECPs with the datasets shared by TSOs with ENTSO-E and ENTSOG, and (b) to agree on an approach to verifying compliance. A notable point of attention will be to differentiate between scenarios and national renewable and energy efficiency target contributions announced in the NECPs, which may not always be aligned.
- | **A precise gap filling methodology should be developed describing how the NECP-based scenarios should be adapted in case the compliance assessment reveals that the NECPs do not reach the Union targets.** Indeed, the current gap-filling approach is well-adapted for small

---

<sup>10</sup> [Link](#)

<sup>11</sup> [Link](#)

---

to moderate gaps relative to EU energy efficiency targets, but is found not to be fit-for-purpose for larger energy efficiency ambition gaps or gaps relative to other targets. Given the significant potential impacts of the design of the gap filling methodology on the scenarios (and therefore on TYNDP and ERAA results), the authors of this report recommend that the European Commission and ACER provide stronger guidance and play a more active role in its validation. A simplified process could be put in place for TYNDP 2026, as the scenario building process is already ongoing, and should not be delayed by introducing a complex validation process for the gap-filling methodology.

### **Challenge #3 – There is a lack of stakeholder engagement, especially in ERAA**

Stakeholder engagement processes are implemented in both TYNDP and ERAA scenario building processes. For the TYNDP, in addition to public-facing stakeholder engagement initiatives, a Scenario Reference Group (SRG) has been set up<sup>12</sup>, in accordance with the TEN-E Regulation and ACER TYNDP Scenario Guidelines. The members of the SRG convene on a regular basis to provide inputs and feedback on assumptions and principles related to scenario building. The members of the SRG represent the views of the industry, associations, and civil society; and operate independently of ENTSO-E and ENTSO-G. Our assessment is that setting up the SRG has proved to be valuable to the overall TYNDP scenario building process, even if some members have mentioned challenges related to the level of effort required to be able to contribute in an effective manner.

By contrast, several stakeholders have underlined the rather low level of involvement of stakeholders in the ERAA stakeholder engagement processes.

#### **Recommendations:**

- | **Extend the remit of the SRG to ERAA.** The authors of this report believe that extending the SRG activities to include ERAA scenarios would be beneficial to provide feedback to ENTSO-E on ERAA scenarios, and to ensure stakeholders better understand the complexity of the ERAA exercise. Given the overlap between the TYNDP and ERAA processes, the “Terms of Reference” of the SRG could be extended to include ERAA’s scenario building process. An alternative option could be to set up a SRG dedicated to ERAA, but this would limit its ability to identify and provide inputs on potential deviations between TYNDP and ERAA scenarios.
- | **Ensure that stakeholders are provided with sufficient visibility and timespan to provide feedback.** Allowing stakeholders (beyond the SRG) to provide useful feedback on all the aspects of TYNDP and ERAA scenarios requires sufficient visibility (what will be consulted when) and an appropriate timespan to provide feedback.

---

<sup>12</sup> [Link](#)

## Challenge #4 – Misalignment of NECP update cycles with TYNDP and ERAA processes, and between TYNDP and ERAA

The misalignment in timing between the ERAA (annual), the TYNDP (biennial), and the NECPs (updated every five years) raises important questions about the reliability and consistency of data sources, particularly in periods where updated NECPs are not available. This temporal mismatch inevitably requires additional data processing and assumptions to fill informational gaps, which in turn increases the degree of discretion in how data are interpreted, adjusted, or extrapolated for use in scenario development process.

Evidence also shows that developing scenarios for the TYNDP on a biennial basis is challenging, as the process often faces delays. In contrast, the annual cycle of the ERAA further limits opportunities for meaningful stakeholder involvement, as the compressed timelines leave little room for consultation, feedback, and iterative improvement.

In addition, ENTSO-E and ENTSO-G have pointed to delays in data submissions by TSOs as a major bottleneck in the overall process. TSOs, for their part, have reported that such delays are often a consequence of late NECP publications, suggesting a knock-on effect across the planning chain.

### Recommendations:

- | **Considering changing the frequency of the ERAA from an annual basis to a biennial cycle to align it with the TYNDP.** On top of enabling a further streamlining of the data collection for the two exercises, this would also allow for more time and opportunities for stakeholders to provide feedback.
- | **The time horizons covered in the scenarios developed for TYNDP and ERAA should continue to have at least one year in common,** to ensure consistency and comparability.
- | **When new NECPs are available, scenarios should be aligned as closely as possible with them.** However, since NECPs are updated every 5 years and that TYNDP and ERAA cycles are more frequent, there will be no available update of the NECP for a subset of TYNDP and ERAA scenario building processes. Nevertheless, EU and/or national energy and climate policy changes can materialise in between NECP updates. **In the period between two NECP updates, changes to scenario assumptions may therefore be justified, but only when triggered by official legislative actions from Member States** (ambitions or political announcements alone should not constitute sufficient justification). Therefore, the authors of this report recommend that for all changes in the assumptions (which would be deviations from the NECPs) a detailed explanation is provided by the TSOs and validated by NRAs (see our recommendations on how to tackle Challenge #1). Moreover, increasing the frequency of the NECPs from 5- to 4-year cycles, could be considered, in order to have updated NECPs every two TYNDP cycles.
- | To ensure the scenarios approach is consistent across cycles, **the authors of this report also recommend the methodology for developing scenarios to remain relatively stable** (e.g., for a period of five years). With a stable scenario development framework, it becomes easier to adapt the data and assumptions where needed. This approach would be similar to the one

being applied for the CBA methodology, where the main building blocks remain stable across TYNDP cycles.

- | **Finally, the authors of this report recommend that a closer alignment between TYNDP and ERAA scenarios should be considered**, not only related to assumptions but also with respect to modelling approaches. Indeed, while acknowledging that certain differences between the modelling approaches (e.g. granularity of the generation mix, use of Monte Carlo approaches, etc.) are justified by the different objectives of the two exercises, a greater alignment could avoid potential inconsistent decisions between TYNDP and ERAA. For example, the way electricity market coupling and hydrogen infrastructure are modelled currently significantly differs between both planning exercises. Examining the merits of a closer alignment of these aspects is encouraged. Furthermore, the authors of this report recommend that national assumptions provided by the TSOs (e.g., demand, capacity mix) be aligned by default during the scenario building phase and that deviations only be introduced if well documented and validated by NRAs (see Challenge #1). In principle, adapting the assumptions to the purpose of the exercise should not be required, as processes are put in place to ensure the scenarios are fit for purpose for infrastructure planning and adequacy assessments (see description of the SoS loop and EVA processes above).

Several additional challenges and associated recommendations are presented in our report, including:

- | Good practices to produce high- and low-economy variants for TYNDP,
- | The elaboration of alternative ERAA scenarios (which might not be compliant with Union energy and climate objectives, and be based on observed trends rather than on the need to meet pre-determined objectives), and
- | The overall transparency of the scenario building processes for both TYNDP and ERAA.

### Note on an effective governance for scenario building

As described in this report, electricity and gas TSOs, ENTSO-E and ENTSG play a key role in the establishment of both TYNDP and ERAA scenarios. Whenever limitations of the scenario building process are identified and associated recommendations are proposed, the authors of this report have carefully reflected on the merits of introducing an alternative governance, where the role(s) played by TSOs and/or ENTSO-E and ENTSG would not be as central as they currently are.

In particular, a series of challenges emerge due to ACER TYNDP Scenario Guidelines identifying NECPs as the basis on which the central scenarios of TYNDP and ERAA are to be established and to the requirement that the TYNDP and ERAA scenarios should be compliant with Union targets. The level of detail of individual NECPs and the level of ambition of the aggregation of NECPs lead to each TSO being required to make judgment calls about national ambitions and impact of policies and to ENTSO-E and ENTSG being required to proceed with filling the ambition gap.

Furthermore, the necessary provision of gap-filling inputs by TSOs can be considered as placing them in a position of perceived conflict of interest. Particularly sensitive topics in this regard include the choice of generation capacity assumptions for ERAA and of final energy consumption for TYNDP.

In this context, a change in the current scenario building governance could be justified to:

- | **Reinforce the credibility of scenarios** to reduce the probability/perception of conflicts of interest, which could be caused by an apparent lack of neutrality, since the interest of TSOs might be that more network infrastructure is built and/or that capacity remuneration mechanisms are put in place to help meet adequacy criteria.
- | **Strengthen the integration of cross-sectoral perspectives** (also in CBAs and System Needs/Infrastructure Gap Identification), as TSOs and ENTSO-E and ENTSG have vector-specific interests and expertise.
- | **Avoid lowest common denominator outcomes**, where scenarios reflect compromises between the positions of TSOs and ENTSO-E and ENTSG, rather than best judgement and exploration of contrasted scenarios (beyond the central scenario).
- | **Improve stakeholder engagement.**

Evaluating the merits of a change of governance should be based on (a) the identification the type of tasks that are being carried out to deliver the TYNDP and ERAA scenarios, (b) the identification of alternatives, and (c) the evaluation of the alternatives against a set of criteria (e.g. technical expertise, perceived legitimacy, ability to engage with stakeholders, etc.).

The tasks to deliver TYNDP and ERAA scenarios can be summarised as follows:

1. **Scenario guidance (Today: ACER):** Establishing expectations related to the design and contents of the scenarios (e.g., ACER TYNDP Scenario Guidelines, ERAA Methodology).
2. **NECP data extraction (Today: TSOs):** Analysing, extracting and interpreting key data from the NECPs (e.g., demand levels, electricity capacity mix, etc.) and sharing them with ENTSO-E and ENTSG.

3. **Additional data collection (Today: ENTSO-E and ENTSG):** Identifying, collecting and validating additional technical data required for the modelling outside of the scope of the data requests made to TSOs (e.g., commodity prices, status of grid projects, CAPEX, techno-economic parameters).
4. **Gap-filling (Today: ENTSO-E and ENTSG):** In the case where aggregated NECP-based datasets shared by TSOs are not aligned with Union climate and energy targets for 2030 and 2050, making targeted adjustments to ensure compliance with the targets.
5. **Guidelines for the implementation of the scenarios (Today: ENTSO-E and ENTSG):** Developing a detailed modelling approach to build the scenarios, in line with the scenario guidance (Step 1).
6. **Stakeholder engagement and transparency (Today: ENTSO-E and ENTSG):** Meaningfully engaging with relevant stakeholders throughout the scenario building process, including through workshops and public consultations, and ensuring transparency over all information and outcomes required for meaningful public scrutiny.
7. **Scenario building phase (Today: ENTSO-E and ENTSG):** Using energy models with the gathered inputs and following the relevant methodologies (Step 5) to develop fully-fledged scenarios.
8. **Regulatory and stakeholder scrutiny (Today: ACER/SRG/EC):** Reviewing the scenario building processes, validating the main assumptions, reviewing the quality of the outputs and the extent to which these meet regulatory requirements (e.g., ACER opinions on the TYNDP Scenarios, TYNDP Stakeholder Reference Group, European Commission approval of TYNDP scenarios).

Different alternative governance options could be considered, with different scopes (e.g. ERAA and TYNDP could be using different governance structures; not all ERAA and TYNDP scenarios could be subject to the same governance, notably since checks and validation steps seem particularly important for the scenarios where TSOs and ENTSO-E and ENTSG must fill gaps compared to the datasets available in the NECPs).

The recommendations provided in this study are associated with incremental governance reforms to strengthen regulatory guidance and oversight of key steps of the scenario building processes for European infrastructure planning and adequacy assessment, namely:

- | the role of NRAs in checking and validating inputs submitted by TSOs to ENTSO-E and ENTSG
- | the role of the European Commission and ACER in defining and validating the gap filling methodology to ensure the central TYNDP scenario and the best estimate ERAA scenario are compliant with the Union targets, even if underlying NECPs are not
- | the role of the SRG in the ERAA scenario building process

These recommendations aim at combining the strengths of all involved stakeholders: the high technical expertise of TSOs, ENTSO-E and ENTSG and the oversight of regulatory authorities and the SRG. Such amendments to the governance of scenario building processes would reinforce the credibility of the scenario building process and reduce the risk of perceived conflict of interest.

# 1 Task 1 – Description and assessment of the current process followed by ENTSO-E and ENTSOG to build scenarios

This chapter outlines the current process followed by ENTSO-E for the development of the ERAA central scenario and by ENTSOG and ENTSO-E for the development of the TYNDP central (NT+) scenario. The various sub-sections examine the key phases of the scenario development process, including: (1) the framework definition, (2) the data collection and validation, (3) the modelling phase and finally (4) the compilation and analysis of results together with the report preparation and publication process. The last sub-section of this chapter is dedicated to the limitations identified throughout the analysis and the associated recommendations.

The analyses of this chapter are based on an in-depth review of publicly available documents<sup>13</sup>, targeted meetings with the ENTSO-E and ENTSOG and other relevant stakeholders<sup>14</sup>, and answers received to a questionnaire addressed to national electricity and gas TSOs<sup>15</sup>.

For the **TYNDP**, the latest version published at the time of preparing this report is the TYNDP 2024. The analysis has been supplemented with publicly available materials of the on-going TYNDP 2026 edition, notably from stakeholder engagement processes organised by the ENTSO-E and ENTSOG (primarily slides). Moreover, given that the *Distributed Energy* and *Global Ambition* scenarios from TYNDP 2024 will no longer exist in TYNDP 2026, the focus has been exclusively on the National Trends+ scenario building process.

For the **ERAA**, the most recent version published at the time this report was prepared is the ERAA 2023<sup>16</sup>. The analysis has been complemented with publicly available materials from the ongoing ERAA 2024 process, notably the data collection guidelines ENTSO-E has prepared to collect data from electricity TSOs, the call-for-evidence on preliminary input data and stakeholder webinars.

A graphical representation of the workflows leading to the establishment of the TYNDP and ERAA scenarios, has been developed. This representation includes the dates based on the 2026 version for TYNDP and the 2023 version for ERAA. However, the focus should not be placed too heavily on the specific dates, as they are intended primarily to illustrate the relative timeframes of the various steps involved in the scenario development process<sup>13</sup>. All the detailed explanation of the different stages, present in the graphical workflow, are detailed throughout the paragraphs of Task 1.

---

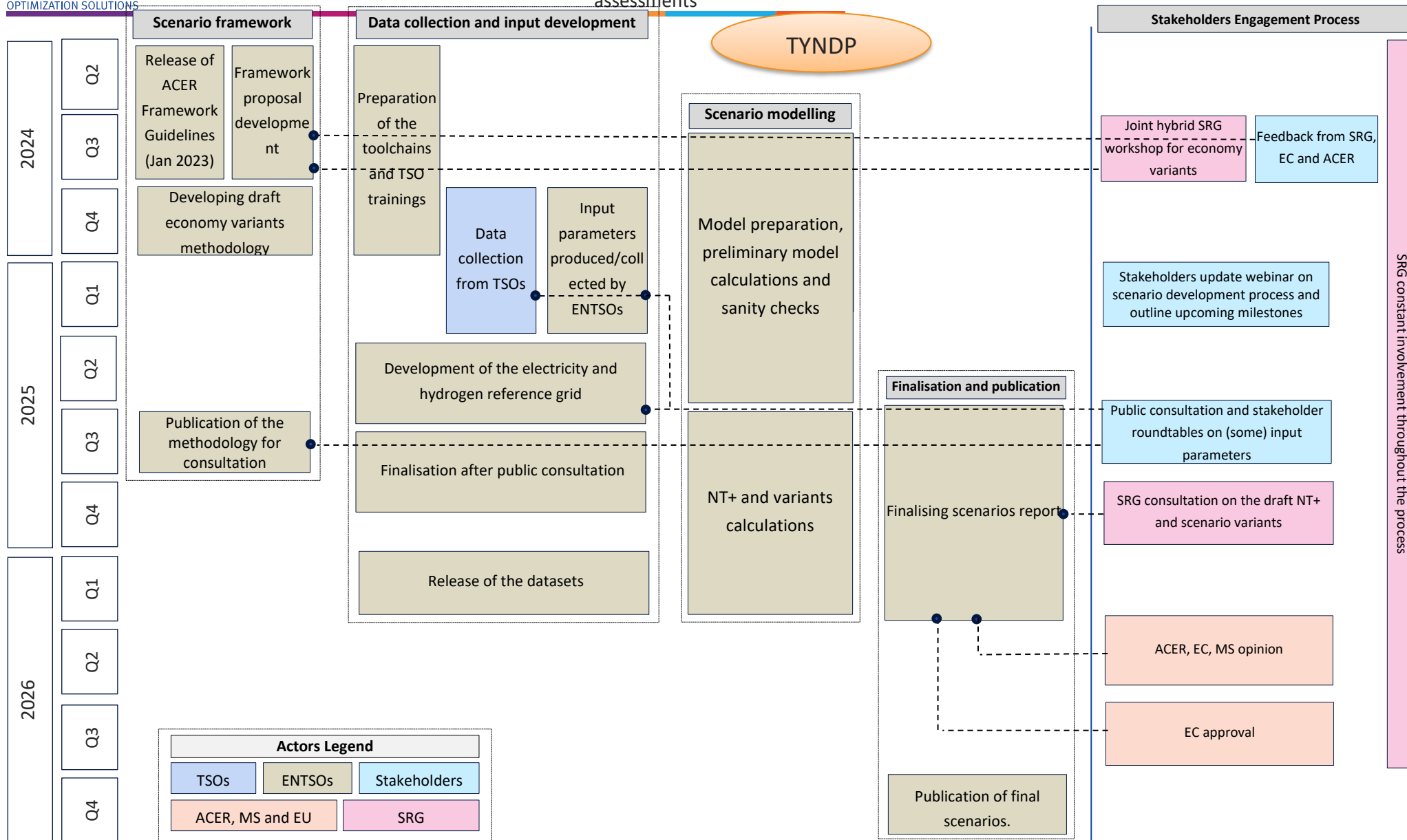
<sup>13</sup> The list of public documents reviewed is available in the annex (section 5.1 *List of public documents studied*).

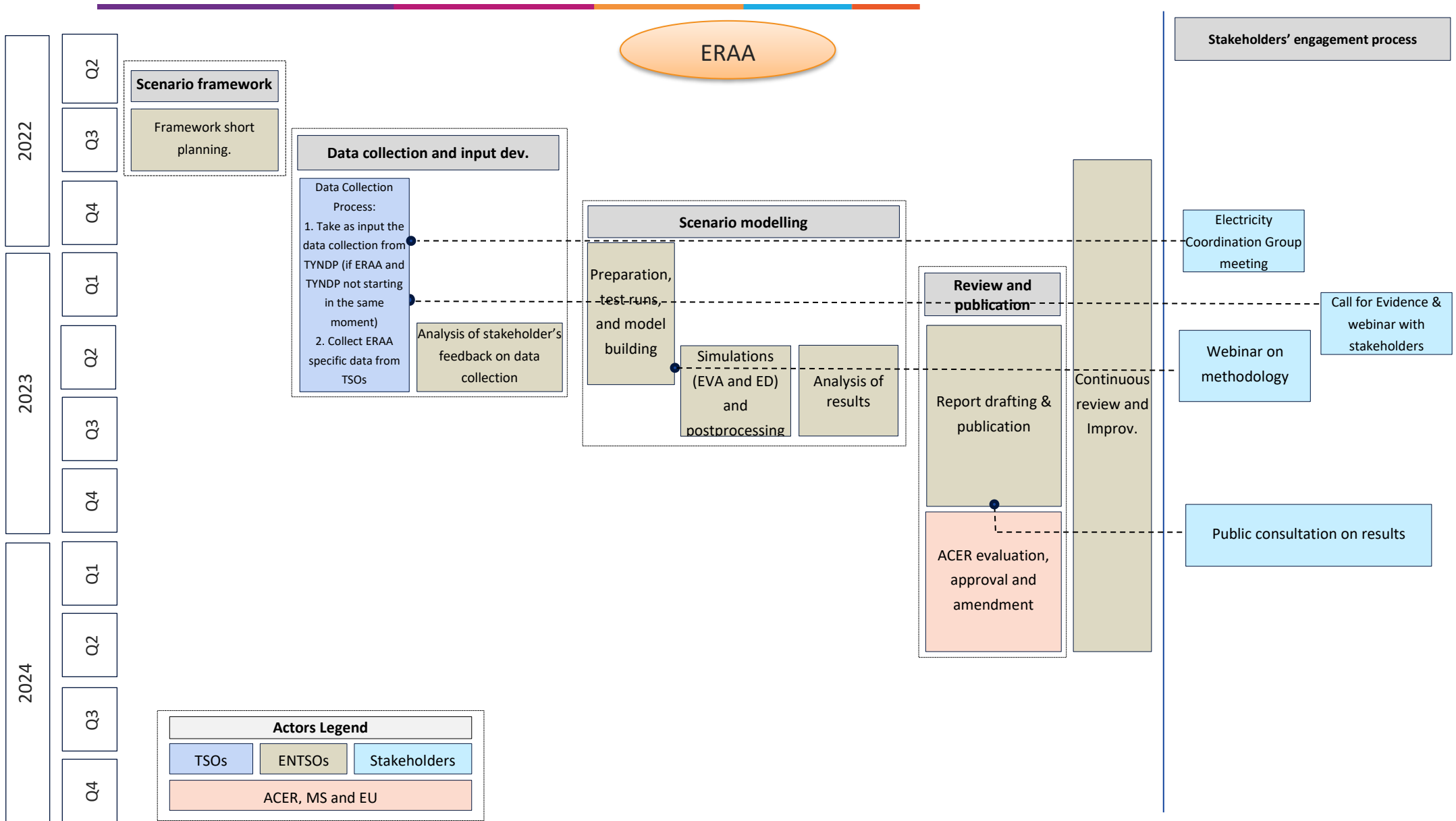
<sup>14</sup> The list of interviews with stakeholders (companies interviewed and duration of the meetings etc.) is available in the annex (section 5.2 *Questionnaire asked to the TSOs*).

<sup>15</sup> The list of questions asked to national TSOs is available in the annex.

<sup>16</sup> ERAA 2024 has been released two weeks before the delivery of the present report

Study to support the development of scenarios for EU-wide infrastructure planning and adequacy assessments





## 1.1 Framework development

### 1.1.1 TYNDP

In May 2024, ENTSO-E and ENTSOG, based on the ACER TYNDP Scenarios Guidelines for the joint TYNDP scenarios<sup>17</sup>, revised the scenario framework of the TYNDP 2024 and presented their updates proposal to the Stakeholders Reference Group (SRG)<sup>18</sup> (whose opinion is independent from TSOs), EC and ACER to collect feedback. A kick-off workshop, which happened on the 4<sup>th</sup> of July 2024, formally marking the beginning of the TYNDP 2026 scenario building process.

This workshop also kicked off work on the so-called “scenarios framework”, which refers to the structured approach used to assess various possible scenarios based on a defined set of assumptions, uncertainties, and variables. For example, the way to implement the variants is a core element of the framework definition.

The main evolution between the TYNDP 2024 and 2026 cycles in terms of framework development concerns the switch from deviation scenarios (Distributed Energy (DE) and Global Ambition (GA)) in the TYNDP 2024 to scenario variants in TYNDP 2026. In TYNDP 2024, the deviation scenarios were treated as standalone scenarios, developed top-down by ENTSO-E and ENTSOG, each requiring a specific storyline, and as evidence of this effort, a dedicated storyline report was produced for TYNDP 2024. For the 2026 economy variants (“low”-economy and “high”-economy variants, which serve as stress-tests of the central scenario) the main high-level principles are defined in the ACER TYNDP Scenarios Guidelines. However, the concrete implementation of the variants requires a considerable amount of discussion and reflection, given the new nature of these scenario variants. The work on developing a new draft methodology for economy variants began in October 2024<sup>19</sup>. A public consultation on the methodology proposed for the TYNDP 2026 was run however only in July 2025.

In the case of TYNDP 2024, after the collection and implementation of the stakeholders’ feedback on the framework proposal, all the data required, from the framework perspective, was available for the scenario building. However, ENTSO-E and ENTSOG only released the formal storyline report after 10-12 months<sup>20</sup>, mentioning in an interview with Artelys that the delay was due to capacity issues caused by the gas crisis.

It should also be noted that ENTSO-E and ENTSOG have renamed the initial phase of the scenario-building process, to reflect its evolving content, particularly following the replacement of the DE and GA scenarios with economy variants. This phase, previously referred to as “Storyline definition” up to the TYNDP 2024 cycle, is now called “Scenarios Framework” starting from the 2026 cycle.

---

<sup>17</sup> See [Link](#).

<sup>18</sup> Stakeholders Reference Group (SRG): independent group of stakeholders created to provide expert input to the development of scenarios. SRG operates independently to ensure that scenarios reflect a balanced variety of interests and expertise from different sectors.

<sup>19</sup> TYNDP 2026 Scenario public timeline.

<sup>20</sup> TYNDP 2024 Storyline Report, page 18.

## 1.1.2 ERAA

During a meeting with ENTSO-E, it was clarified that, in contrast with TYNDP scenario development process, there is currently no formal process in place for establishing a coherent ERAA storyline or overarching framework. More specifically, for ERAA, most of the work is focused on methodological improvements to be established in the current edition compared to the previous one, considering the feedback received during the previous cycle. ENTSO-E noted that the time is allocated internally to discuss elements such as sensitivity analyses, potential additional scenarios, and key assumptions. In our understanding, decisions made during this internal process are not subject to external stakeholder review.

## 1.2 Scenarios inputs

### 1.2.1 Inventory of scenario inputs

The “inputs” to the scenarios can be distinguished in:

- | High-level drivers: broad, influential factors, such as economic development, population growth, policy shifts, shaping the whole scenarios.
- | Parameters: quantifiable variables that define the scenario’s details, such as the detailed behaviour of the production assets.
- | Assumptions: for each parameter, a given value is chosen, and this value is called “assumption”.

Considering that TYNDP and ERAA central scenarios must be aligned with EU policies, targets and objectives and, to the extent possible with NECPs<sup>21</sup>, the high-level drivers have not been defined by the ENTSO-E and ENTSG because they were already established by the EU political agreed policies and by the Member States for the development of the NECPs. As further explained later, the ENTSO-E and ENTSG fully rely on the TSOs to reflect these drivers when submitting data through the Energy

---

<sup>21</sup> For TYNDP scenarios, the TEN-E regulation (Article 12(1), second paragraph - [link](#)) requires the scenarios to be “in line with the energy efficiency first principle and with the Union’s 2030 targets for energy and climate and its 2050 climate neutrality objective” and to “take into account the latest available Commission scenarios, as well as, when relevant, the national energy and climate plans.” Additionally, as indicated in the same Article 12, the ENTSO-E and ENTSG shall also follow ACER TYNDP Scenarios Guidelines .

ACER TYNDP Scenarios Guidelines ([link](#)) also states that “ENTSOs are expected not to deviate from those [EU energy and climate] politically agreed policies, targets and objectives”, while recognising that reasonable and pragmatic deviations are allowed as long as explicated and justified in the draft scenario reports (article 23). Article 31 states than “The ENTSOs shall consider the NECPs, if up to date, as the basis for developing scenarios.”

For ERAA scenario, ACER’s Methodology for the European resource adequacy assessment ([link](#)) requires “The baseline data for the ERAA stems from the national projected demand, supply and grid outlooks prepared by each individual TSO. These national forecasts shall be consistent with existing and planned national policies, including: (a) national objectives, targets and contributions, and other projections contained in the NECPs [...]” (Article 3(3)).

Transition Model (ETM). The introduction of the Energy Transition Model (ETM) for the National Trends demand data collection from the TYNDP 2026 cycle is an effort to collect in a uniform format NECP demand-drivers (but suffers from implementation issues for now – as described in section [1.3.2.1 Energy transition model \(ETM\)](#) of the present report).

As scenario input, NECPs hold significant potential to inform both Pan-European exercises. However, in their current form, the plans vary considerably across countries in terms of granularity, structure, and the accessibility of underlying data. These inconsistencies present a substantial challenge when attempting to translate the NECPs into coherent modelling inputs. The lack of standardisation hinders comparability and complicates efforts to ensure alignment across Member States.

The inventory of scenario input parameters and assumptions has been developed as an Excel spreadsheet and is available as an annex. This file compiles the list of all input parameters, along with the following information:

1. Name of the specific parameter.
2. Scenario – Whether the parameter is used in both ERAA and TYNDP, only in ERAA, or only in TYNDP<sup>22</sup>.
3. Source of the parameter:
  - a. Whether it is collected from TSOs or other external institutions/stakeholders, established in-house by ENTSO-E and ENTSG, and/or directly sourced from NECPs.
  - b. Whether it is a pure input (taken as given from TSOs) or intermediate result (internally processed through other methodologies/tools).
4. Data provider – Whether the parameter has been provided by TSOs or other sources.
5. Detailed parameter information:
  - a. Description of the parameter
  - b. Role in the scenario-building process
  - c. Time span for which parameter data is provided
  - d. Relation to other inputs
6. Example assumption value – A direct example of an assumption value for the parameter, where available.
7. ENTSO-E and ENTSG' level of expertise – Assessment of ENTSO-E and ENTSG' knowledge and competence in defining and quantifying the drivers, parameters, and assumptions required for scenario development.

The parameters are grouped by sector (electricity, hydrogen, methane and other) and category (consumption, production, transmission/grid, storage, commodity price and others).

---

<sup>22</sup> Divergences in the values, for the same parameter, for ERAA and TYNDP, are specified in Task 3.

## 1.2.2 Input data construction process

As outlined in the inventory of scenario inputs presented above, scenario inputs can be clustered into two main categories:

- | **The “TSO” assumptions collected bottom-up from ENTSO-E’s and ENTSOG’s members** (national electricity and gas TSOs).
- | **The “ENTSO” assumptions developed centrally by ENTSO-E’s and ENTSOG’s teams** (potentially relying on preliminary models) or collected from external sources (but with a unified source over the whole modelled geographical scope).

This section focuses on the data collection processes for the “TSO” assumptions – i.e. the efforts to collect input data from the national TSOs in a bottom-up approach. The “ENTSO” assumptions built centrally or collected from a unique external source for the whole of Europe are described in the previously mentioned inventory of scenario inputs.

### 1.2.2.1 Process overview

For sake of clarity, this section presents the TYNDP and ERAA scenario input development processes separately. The synergies and common data processes between TYNDP and ERAA are made explicit in section 3.

#### i. TYNDP data collection process overview

The TYNDP data collected from TSOs can be divided into three main components:

- | **The data collected by ENTSO-E from electricity TSOs** on the power system, through the Pan-European Market Database (PEMMDB) App<sup>23</sup>.
- | **The data collected by ENTSOG from gas TSOs** on methane and hydrogen systems. This data collection happens through the exchange of Excel files
- | **The demand data for all energy carriers**, jointly provided by electricity and gas TSOs, through the Energy Transition Model (ETM).

#### Overlaps between the sources and required coordination between electricity and gas TSOs

Electricity and gas TSOs are supposed to coordinate on two types of assumptions: energy demand projections for all energy carriers<sup>24</sup> and generation technologies at the interface between electricity, methane and hydrogen systems (e.g., gas-fired power generation).

**For the energy demand projections**, national electricity and gas TSOs must coordinate and provide one unique demand projection which covers all energy carriers. It is important to highlight that electricity and gas TSO are jointly responsible for providing demand-related inputs for all energy carriers. Indeed, ENTSOG and ENTSO-E send a single request to national electricity and gas TSOs, who must submit one single answer by country. In other words, the electricity demand assumptions are not

<sup>23</sup> More information on the PEMMDB App is available in paragraph [ii. ERAA data collection process overview](#).

<sup>24</sup> Energy carriers: electricity, biofuels, hydrogen, methane, heat, liquids, solids, others.

provided solely by the electricity TSOs, and gas demand assumptions are not provided solely by the gas TSOs. Instead, gas and electricity TSOs must coordinate to provide a joint projection which covers every energy carrier.

**For generation technologies at the interface** between electricity, methane and hydrogen (e.g., gas-fired power generation), electricity and gas TSOs are also supposed to coordinate and align their views. However, contrary to demand projections, these data are submitted twice in distinct data collection processes: by gas TSOs to ENTSOG on one side, and by electricity TSOs to ENTSO-E on the other side. Even though electricity and gas TSOs are supposed to coordinate to provide consistent assumptions.

Table 1 – Data collection process information provides an overview of the division of responsibilities, and the different tools used, for data collection between the ENTSO-E and ENTSOG.

**Table 1 – Data collection process information**

Parameter	Aligned with NECP	ENTSO-E & ENTSOG joint data collection	ENTSO-E data collection	ENTSOE data collection	Collection tool /methodology
Energy demand (NT+) for all energy carriers	✓	✓			ETM
Gas-fired power generation capacity	✓		✓	✓	PEMMDB (ENTSO-E) and Excel (ENTSOE)
Other power generation capacities	✓		✓		PEMMDB
Battery capacities (prosumer and market participating)	✓		✓		PEMMDB
DSR (capacity and activation price bands)	✓		✓		PEMMDB
Grid connected electrolyser capacity	✓		✓	✓	PEMMDB (ENTSO-E) and Excel (ENTSOE)
SMR capacities (details on with or without CCS)	✓			✓	Excel files
Baseline projections of Net Transfer Capacities (NTCs)	✓		✓		NTCs collected through PEMMDB.
Hydrogen reference grid	✓			✓	Excel files
Domestic production for natural gas, liquids, biomass, hydrogen	✓	✓			Excel files
Biomethane potentials				✓	Excel files
Import potentials for hydrogen, ammonia and methane.				✓	Excel files

### Electricity reference grid construction process

Among the input parameters needed for the modelling, ENTSO-E develop the electricity reference grid, which represent NTC interconnection capacities between market zones in the market model. For the TYNDP 2024 cycle, the reference grid was built for three time-horizons: the first mid-term horizon (2025), the second mid-term horizon (2030), and the long-term horizon (2035). The reference grid 2030 was used for the National Trends+ 2030 scenario, and the reference grid 2035 was used for the National Trends+ 2040 scenario.

It should be highlighted that the reference grid used in the TYNDP scenario building process differs from the reference capacities subsequently used in the cost-benefit analysis phase. This section is only about the construction process of the reference grid used in the scenario building phase (and do not reflect the construction process of the reference grid used for the CBAs).

The building process is the following: TSOs provide projected baseline NTCs to ENTSO-E for each of the time horizon considered for the scenarios. The latter also collects the different grid projects (using the criteria mentioned in the CBA 4<sup>th</sup> Guidelines<sup>25</sup> which specifies that only those projects whose timely commissioning is reasonably certain are to be included in the reference grids). Afterwards, ENTSO-E calculates the delta NTCs caused by each of the new projects. Then, ENTSO-E determines the projects to be considered as part of the reference grid at the different horizons. Finally, ENTSO-E computes the NTC capacities composing the reference grid at the different horizons by adding the delta NTCs delivered by the projects included in the reference grid to the baseline projected NTCs. During interviews, ENTSO-E reported that one of the difficult parts of this process was to receive information from the TSOs on which new projects are already considered as commissioned in the “baseline projected NTC” and which are not.

It must also be noted that, in its opinions on the past versions of the TYNDP, ACER has highlighted inconsistencies in the capacity assumptions used to define the reference grids, notably vis-à-vis the application of the criteria set out in the CBA 4<sup>th</sup> Guidelines.

### Hydrogen reference grid construction process

The input data for the hydrogen reference grid are collected by ENTSG from TSOs and third-party project promoters. These data include hydrogen transmission, storage, and liquefied hydrogen import terminals.

For the TYNDP 2024 scenarios, the hydrogen reference grid included all hydrogen projects submitted to TYNDP 2022, regardless of their maturity level. This approach can be considered as being too optimistic, as only a subset of these projects will obtain the PCI/PMI label, and most of them are still far from reaching FID.

---

<sup>25</sup> See [Link](#)

For TYNDP 2026, a more conservative approach has been proposed: for the short- and medium-term horizons (i.e., 2030 and 2035), only PCI/PMI projects from the most recent completed selection process, or projects that have reached an advanced<sup>26</sup> maturity status, will be considered in the hydrogen reference grid.

Despite these improvements, it should be noted that the proposed hydrogen reference grids for 2030 and 2035 still appear to be rather optimistic compared to the way the electricity reference grid is built (with only probable projects that have reached a high level of maturity). Indeed, the proposed approach for TYNDP 2026 include in fact all PCI/PMI projects, even those with less advanced maturity. It could also be argued that even the so-called advanced projects may represent an optimistic outlook, especially for 2030, given the early stage of development of the hydrogen system and infrastructure, as well as the likelihood of delays.

In the other hand, it is not clear that the hydrogen reference grid should be defined in the same way as the electricity reference grid, i.e. by considering only probable projects. Indeed, a notable difference of the hydrogen network compared to the electricity network is its embryonic state, and therefore that the level of infrastructure when considering only probable projects is very low. Consequently, if scenarios include an optimistic or bullish outlook in terms of hydrogen offtake and deployment of e.g. electrolysis in Europe, whilst at the same time infrastructure reference levels to be used in subsequent CBAs are based on conservative project-related observations, then one may end up in a situation where almost all infrastructure projects will have a positive CBA result. In our opinion, using a similar approach to defining infrastructure levels and demand/supply outlooks should be favoured (rather than a similar approach as for the electricity reference grid) to avoid overestimating the benefits brought by projects.

---

<sup>26</sup> See the presentation of ENTSO-E and ENTSG's Draft Scenarios Public Consultation Workshop held on 4<sup>th</sup> July 2025 – [Link](#) (slide 74)

### Recommendation 1 – Transparency of the construction process of the electricity and hydrogen reference grids

The construction process of the electricity reference grid and of the hydrogen reference grid should be more transparently described in ENTSO-E and ENTSOG publications and the reference grids composition should be subject to public consultation before its actual consideration in the scenario development process or, at least, subject to the scrutiny of the European Commission, ACER and NRAs.

This could take the form of an Excel document describing, for each border:

- | The capacities projected values provided by the different TSOs
- | The list of projects assumed by the national TSOs to be commissioned at the different horizons (i.e. the list of projects already taken into account in the capacity projected values provided by the different TSOs)
- | The list of projects included and excluded from the TYNDP reference grid<sup>27</sup> together with the criteria met for their inclusion in the concerned reference grid.
- | The individual impact of each project on the additional capacity/net transfer capacity<sup>28</sup>
- | The resulting capacities in the reference grid at the different horizons.

Finally, even if it may be justified to apply a different combination of criteria when building the electricity and hydrogen reference grids, ENTSO-E and ENTSOG should align in type of information to be collected concerning the project maturity criteria, and the data collection for the electricity reference grid and the hydrogen reference grid should still be done jointly by the ENTSO-E and ENTSOG (i.e. should at least happen at the same time and with the same process). Any difference in the way the collected criteria are then used to build the grid (for instance, if additional hydrogen projects are included at specific interconnection points to ensure that a certain adequacy level is reached) should be properly justified and subject to consultation.

### Considerations about the missing methane infrastructure modelling

No joint electricity-hydrogen-methane dispatch model has been developed or used as part of the TYNDP 2024. In particular, methane infrastructure (storages, cross-border pipelines, LNG terminals) is not represented in the TYNDP 2024 multi-energy model jointly developed by ENTSO-E and ENTSOG (which only represents the dispatch of electricity and hydrogen). While methane exclusion risks inconsistencies in demand/supply evolution (particularly for hydrogen repurposing assumptions),

---

<sup>27</sup> This information was available in the project sheets until TYNDP 2022 cycle but couldn't be found in TYNDP 2024 project sheets. Moreover, even in TYNDP 2022, this information was difficult to find because only available in the project sheet of each project (and not in a single document for all projects) and was only published at the same time as the scenarios (project sheets are only published at the end of the TYNDP process, when the CBAs are carried out).

<sup>28</sup> Similarly to the list of projects included in the reference grid, the individual impact of each project is also available in the project sheets, couldn't be found in a unique file for all projects, and were only made available after the publication of the project sheets.

estimating the amount of methane infrastructure which could be repurposed without putting the methane system at risk requires more detailed models than the TYNDP multi-energy model anyway, because:

1. Methane infrastructure needs must be assessed under stress tests (where the TYNDP scenarios mainly represent normal conditions)
2. Intra-national methane grid dynamics (such as internal congestions, routes with several physical pipelines, etc.) must be represented to determine repurposing possibilities.

The model's current resolution cannot adequately simulate methane grid dynamics or stress conditions required for accurate repurposing assessments. ENTSOG's Dual Gas Model would be better suited for this, and the output of the DGM could be used as input to the TYNDP multi-energy model (the two models are too different to be unified). Furthermore, methane infrastructure is largely ineligible for PCI/PMI status under TEN-E, reducing immediate modelling priorities for expansion projects. However, Article 11(10) of TEN-E mandates future 'interlinked' gas/hydrogen planning, suggesting methane representation may need enhancement in later TYNDP cycles to ensure consistency with ENTSOG/ENNOH responsibilities and integrated NDPs.

### Data collection timeline

For TYNDP 2026, the data collection process started in April 2024 and ended in July 2025, lasting fifteen months. More specifically, the first 8-10 months are dedicated to the preparation of the tools for data collection and TSOs trainings, while during the subsequent months the real data collection took place. At the time of writing, the public consultation on input parameters is happening<sup>29</sup>.

#### ii. ERAA data collection process overview

The ERAA's data collection process is simpler than the TYNDP's, given that the data to be provided is restricted only to electricity. compared to TYNDP as well as no involvement of ENTSOG. Most inputs are gathered through the Pan-European Market Database (PEMMDB) and Demand Forecast Tool (DFT). A high-level list of the input parameters provided through the PEMMDB App for the ERAA includes:

- | Explicit and implicit demand-side response information
- | Renewable plants: installed capacity, commissioning and decommissioning dates, plant location and connectivity to the network
- | Thermal and nuclear plants: installed capacity, commissioning and decommissioning dates, plant location and connectivity to the network, must-run obligations, min-max unit maintenance, planned and forced outages
- | CCS and biofuel units (Boolean)
- | Derating data

---

<sup>29</sup> [Link](#)

- | Inelastic generation profiles
- | Reserves requirements
- | Storage: available capacity, batteries additional information, and hydrogen storage connected to fuel cell units
- | Electrolysers: installed capacity, efficiency, and must-runs criteria

An in-depth analysis of all the inputs is provided in the excel inputs matrix.

ENTSO-E provided guidance to TSOs on the how and which specific input parameters need to be collected with detailed data collection guidelines, which are publicly available<sup>30</sup>. ENTSO-E has also organised a series of training and workshops on the tools used for data collection (PEMMDB App and DFT), the recordings of which are publicly available<sup>31</sup>. For the data collection through the PEMMDB App, TSOs can directly use the App to provide the data requested by ENTSO-E.

### Data collection timeline

ENTSO-E collects data for the ERAA on an annual basis. At the time of writing, the data collection for the ERAA 2025 was under finalisation. For the ERAA 2024, the data collection lasted from November 2023 to mid-August 2024, while in ERAA 2023 from autumn 2022 until summer 2023<sup>32</sup>.

The scope and timeline of the data collection exercise organised by each of the ENTSO-E and ENTSOG (or jointly setup by both ENTSO-E and ENTSOG for a subset of parameters) is found to be challenging by some TSOs. Most of the challenges referred to the amount of data and granularity required by the ENTSO-E and ENTSOG. It happened that TSOs did not have, partially or fully, the data required, therefore they had to either produce it or take them from external sources, which then increased the time needed to accomplish the task. Indeed, not all TSOs submit their input to the data collection on time<sup>33</sup>, which sometimes brings the ENTSO-E and ENTSOG to use values from the previous editions to fill the gaps<sup>89</sup>. Furthermore, when asked to identify the main difficulties encountered during the scenario development process, ENTSO-E explicitly highlighted the issue of limited time. As ERAA is a yearly exercise, all phases, from data collection to modelling, report drafting, and final publication, must be completed within a single calendar year. This short timeframe places significant pressure on the process and can jeopardise the overall quality and robustness of the results, as it often requires a trade-off between completeness and timeliness.

### 1.2.2.2 Sources used by the national TSOs and difficulties encountered

According to the ACER TYNDP Scenarios Guidelines, TSOs are supposed to take NECPs into account to the extent possible for the data collection (see [footnote 21](#) on page 23). However, answers to a

---

<sup>30</sup> At the time of writing this report, only ERAA 2024 data collection guidelines ([link](#)) were available. For this reason, most of the information in the present report is taken from this version. The data collection guidelines for ERAA 2025 are now also available ([link](#)), but have not been studied in detail in this project.

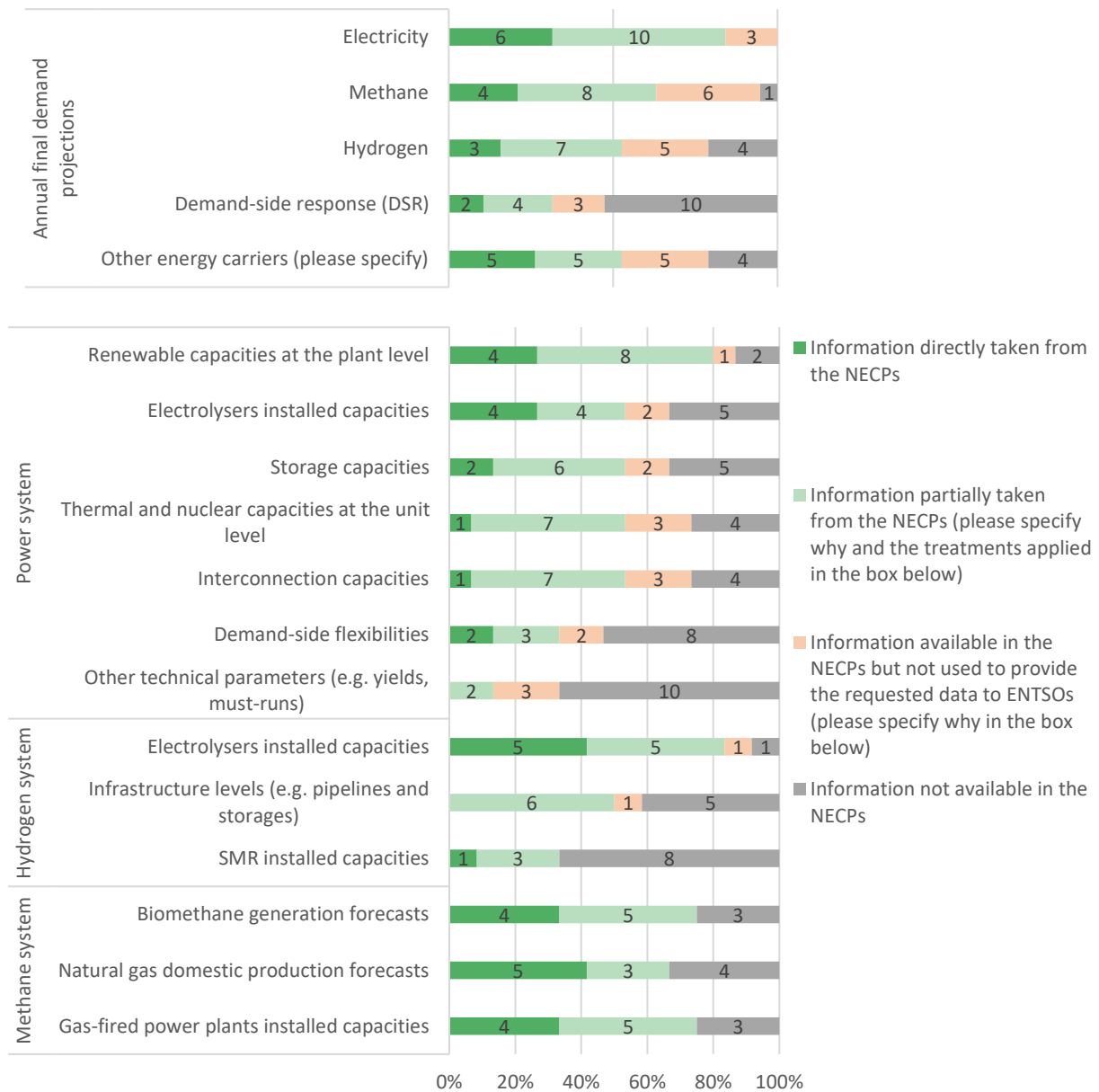
<sup>31</sup> See [Link](#)

<sup>32</sup> ERAA 2023 Annex 1: Input Data and Assumptions, page 3.

<sup>33</sup> Source: Meeting between Artelys and the ENTOSOs

questionnaire sent to TSOs has highlighted that the data provided by TSOs is in reality only partially based on NECPs. [Figure 2](#) illustrates the extent to which the TSOs relied on the NECPs of their respective countries to provide the different data requested by ENTSO-E and ENTSG. The questions related to annual final demand projections have been asked to both electricity and gas TSOs (who are jointly in charge of providing the values for all energy carriers), whereas questions on the power system have only been asked to electricity TSOs and questions on the methane and hydrogen systems have only been asked to gas TSOs. For each question, the numbers on the bars correspond to the number of respondents.

To what extent did you rely on your NECP to provide the following datasets requested by ENTSGs (for electricity TSOs, this question applies to both ERAA and TYNDP)?



**Figure 2 – Sources used by the national TSOs to provide the data what extent did you rely on your NECP to provide the following datasets requested by ENTSO-E and ENTSG<sup>34</sup>. [Source:](#) Artelys’ survey to electricity and gas TSOs**

According to the TSOs’ answers to the questionnaire, the main sources of information used when not directly relying on the NECPs are:

<b>Input parameters</b>	<b>Other sources</b>
<b>Annual final demand projections</b>	TSOs internal projections/scenarios (90% of the answers)
	External sources, specifically for hydrogen: Hydrogen Import Strategy, Core Hydrogen Network, H2 Backbone study (10% of the answers)
<b>Power system</b>	TSOs internal projections/scenarios (70% of the answers)
	External studies (20% of the answers)
	Market participants (e.g. plant owners) consultation (10% of the answers)
<b>Hydrogen system</b>	External sources (50% of the answers)
	TSOs internal projections/scenarios (50% of the answers)
<b>Methane system</b>	TSOs internal projections/scenarios (50% of the answers)
	External sources (50% of the answers)

**Table 2. List of alternative source to the NECP.**

The reasons why the national TSOs do not solely rely on the NECPs are shown in the paragraphs below.

---

<sup>34</sup> Questions on the power system were only asked to electricity TSOs (the sum of the numbers on the bars equals to the number of electricity TSOs who answered the questions - 15).

Questions on the hydrogen and methane systems were only asked to the gas TSOs. In some countries, several gas TSOs replied to the survey. In this case, the answers of different companies from a same country have been compared, merged and counted as 1 on the graph above (the sum of the numbers on the bars equals to the number of gas TSOs from distinct countries who answered the questions - 12).

Questions on the annual final energy demand projections were asked to both electricity and gas TSOs. For the countries for which several companies (e.g. both electricity and gas TSOs) replied, their answers have been compared, merged and counted as 1 on the graph above (the sum of the numbers on the bars equals to the number of distinct countries for which at least one TSO answered the survey – 19).

For electricity TSOs, this question applies to both ERAA and TYNDP.

i. Some NECPs data are not fully available

NECPs often present issues such as a lack of information, insufficient detail (e.g., the inclusion of graphs without corresponding precise numerical values). 70% of the national TSOs who responded to the survey reported NECPs not being publicly available in their entirety (including detailed values and the numerical data behind the graphs presented in the report).

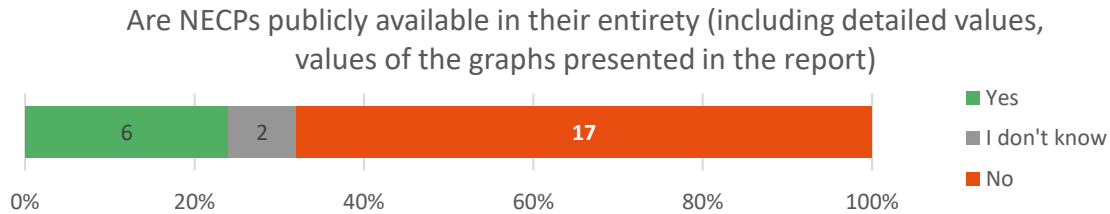


Figure 3 – Data availability in the NECPs. Source: Artelys’ survey to electricity and gas TSOs

Moreover, some NECPs do not provide sufficient level of detail on some parameters. As highlighted on Figure 2, the extent to which TSOs rely on the NECPs varies widely among the type of data. These disparities in the degree of the use of NECPs are largely explained by the disparities in the level of detail provided by the NECPs themselves, which varies from one parameter to another.

Examples of information that is less frequently available in the NECPs includes:

- | SMR installed capacities
- | Technical parameters of power plants (yields, must-run constraints etc.)
- | Electricity demand flexibility
- | Hydrogen infrastructure levels (pipelines and storage)
- | Electricity interconnection levels

When NECPs are not fully available, the TSOs have reported the following workaround solutions:

If NECPs are not fully publicly available, how did you proceed to obtain missing data?

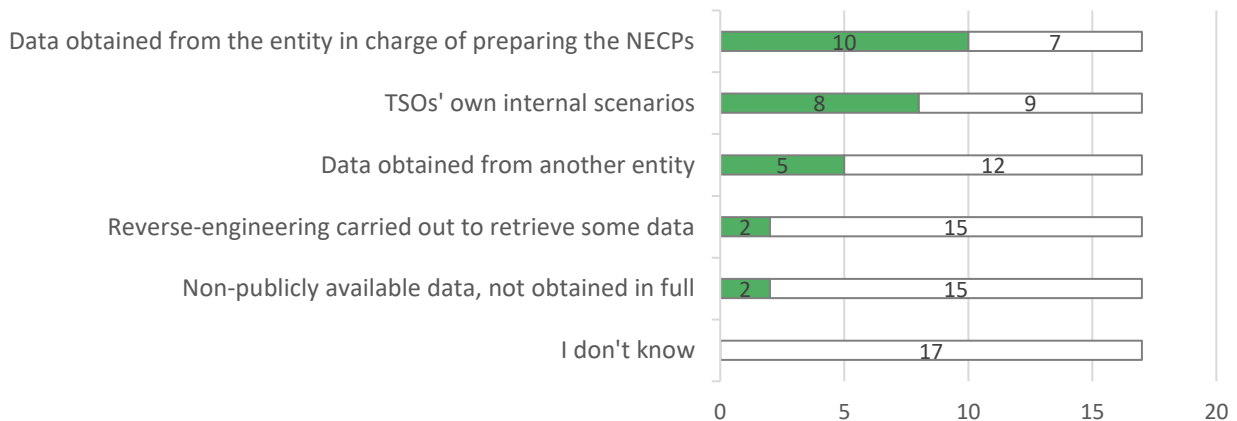


Figure 4 – Workaround solutions in case of NECPs are not fully publicly available. Source: Artelys’ survey to electricity and gas TSOs

The fact that a significant number of TSOs directly contact the entities responsible for preparing the NECPs highlights a clear need for improvement in terms of the clarity and completeness of these documents. A more detailed and publicly accessible dataset would greatly streamline the data collection process for TSOs and reduce the need for repetitive, bilateral exchanges between TSOs and the NECP-preparing entities.

One of the main issues contributing to this problem is the fact that Member States (MSs) are not obliged to complete the Annex I in part 2 of the NECPs, which is the section where all the detailed quantitative data used in the scenarios should be reported. As a result, MSs often fill it in only partially and inconsistently, leading to a lack of uniformity and completeness in the data provided.

The lack of standardisation of the format of the NECPs across Member States (in terms of structure, detail, and scope) also creates difficulties at the validation stages of the process, where this heterogeneity of NECPs significantly complicates efforts to cross-validate TSO-submitted data in a centralised way.

### **Recommendation 2 – Lack of detail in the NECPs**

The authors of this report recommend that ENTSO-E and ENTSOG suggest amendments to the contents of Annex I of the Governance Regulation<sup>35</sup>, which is the section of the Regulation that outlines the specific requirements and templates to be used in NECPs. For example, Member States could be required to complete and publish Annex 1 Part 2 using a harmonised format (e.g. Excel). This guidance should provide Member States clear instructions on the expected level of detail, (including time resolution, units, and disaggregation) required to carry out the TYNDP and ERAA scenario building processes.

This guidance should also include sufficient explanation to Member States about the rationale for providing these details, as they might not be currently aware that NECPs are crucial in European infrastructure planning exercises and adequacy assessments.

Such a requirement would ensure that the data TSOs, ENTSO-E and ENTSOG need for scenario building is delivered uniformly and consistently across all Member States. The intent of this recommendation is not only to reinforce transparency, but also to allow all interested stakeholders to easily assess the compliance of TYNDP/ERAA scenarios with the NECPs.

The recommendation of standardising the NECP formats and improving the level of detail provided across Member States has also been suggested by some TSOs in the survey.

---

<sup>35</sup> [Link](#)

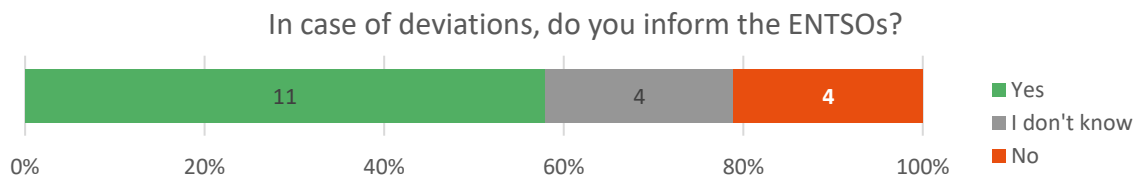
**TSOs’ own scenarios are often used by the TSOs as a workaround**

Another frequently used approach, when information is not available in the NECPs, is the use of TSOs’ own internal scenarios. However, the level of transparency on the TSOs’ internal scenarios inputs and input building process varies from one TSO to the next, which does not always allow for examination/verification. Mixing assumptions from different sources raises the question of the consistency between the sources, which lead to increasing the risk of a “patchwork effect”.

However, the survey to national TSOs carried out as part of this project highlighted that, even when the information is available in the NECPs, it is not always used. 60% of the respondents declared to deviate from information available in their national NECP when providing the required datasets to ENTSO-E and ENTSOG, which may also result in a “patchwork effect”, as mentioned above. The data most frequently available but not used is final demand for hydrogen, methane, other vectors and electricity. In some cases, deviations (despite the availability of the information in the NECPs) were also reported by the TSOs on electricity capacity projections (for renewable, thermal, storage, interconnections), electricity flexibility levels, electrolyser and hydrogen infrastructure levels and other technical parameters of power plants. Mostly, the reasons for these deviations given by the TSOs are:

- | NECPs data that are no longer up to date, due to recent changes in trends or political announcements.
- | Lack of detail in the NECPs obliged them to deviate using their own scenarios.
- | TSOs of two countries mentioned their NECPs were not compliant with the energy & climate objectives (one of the two only at the 2040 horizon, and the other did not further specify).

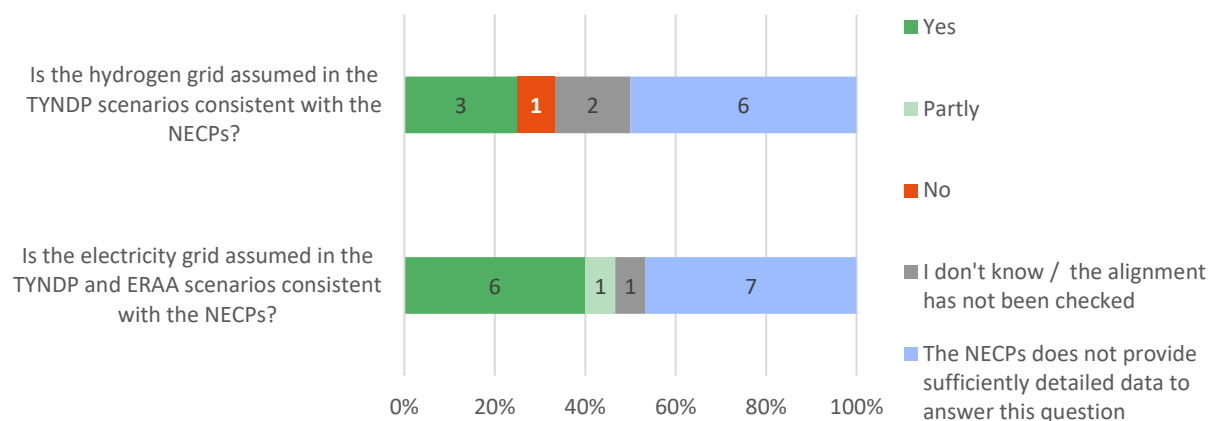
When TSOs deviate from the NECPs, most of the respondents declare to inform the ENTSO-E and ENTSOG.



**Figure 5 – Level of transparency when TSOs deviate from the values present in the NECPs.**  
Source: Artelys’ survey to electricity and gas TSOs

There is currently no publicly available information indicating whether, and to what extent, individual TSOs deviate from the values presented in their respective NECPs, nor is it clear for which specific parameters such deviations occur. Additionally, it seems that TSOs are not formally required to communicate or validate these deviations with ENTSO-E and ENTSOG or any other party during the data collection process.

For the grid data, approximately half of the respondents declare that the NECPs do not provide sufficiently detailed information to determine if the values provided to ENTSO-E and ENTSOG comply with NECPs, as displayed in the figure below.



**Figure 6 – Compliance of the electricity and hydrogen grid data provided by the national TSOs with the NECPs.**  
Source: Artelys’ survey to electricity and gas TSOs

### Recommendation 3 – Transparency of the sources used by the TSOs to provide national data

In case the data is not available in the NECPs, or it is available but TSOs decide to deviate using other sources of data, they should increase the transparency related to the data sources being used to build the scenarios and justify the choices they made. This is already implemented in ERAA, with the publication of the TSO survey on scenario assumptions<sup>36</sup>. This good practice should be extended to TYNDP or mutualised between both exercises.

The transparency could be enhanced with a system of tags on input data, enabling TSOs to clearly report whether the data was taken from the NECP, not available in the NECP or available in the NECP but not followed. The system should also allow TSOs to add further explanations. In the case where information is available in the NECP but not followed, providing a justification, as well as the value from the NECP could be mandatory.

Based on this enhanced transparency provided by the TSOs, ENTSO-E and ENTSOG could publish a “scenario input provenance report” for each cycle, or more simply a summary table listing all NECP parameters used, indicating whether they were used as-is, adjusted, or replaced, and estimating the cumulative value of the deviation from the NECPs. This should include details on who performed the changes (TSO or ENTSO-level), why, and based on what data. This would allow full replicability of the scenario-building process.

- | Fallback solution: At a minimum, ENTSO-E and ENTSOG should ensure that any changes to NECP inputs are flagged and mentioned in the scenario methodology document, even if they are not reported in detail. This is a fallback option that partially improves accountability but does not ensure replicability.

<sup>36</sup> ERAA 2024 – Annex 1: Input data – Appendix 1: TSO survey on scenario assumptions (page 44 to 111).

Finally, NRAs could be involved in the scrutiny of assumptions shared by TSOs with ENTSO-E and ENTSOG, with a particular focus on assumptions where deviations with respect to NECPs are introduced and/or where NECPs are not providing the required information (see [Recommendation 6](#)).

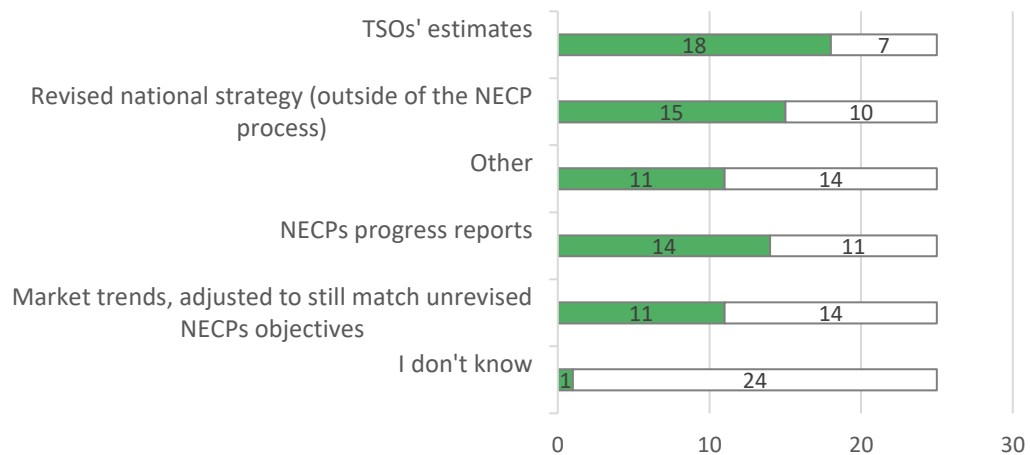
These two cross-cutting recommendations would help to mitigate several risks, notably the data unavailability risk, the risk of a “patchwork effect” that this entails as well as all other difficulties encountered described in the rest of [Section 1.2.2.2](#).

**ii. NECPs update cycles are not always aligned with data collection timelines**

The difference in timing between the ERAA and TYNDP cycles (annual and bi-annual respectively) and the updating of NECPs (every 5 years) raises the question of which data sources to use in the absence of regularly updated NECPs.

Options considered by the TSOs to provide up to date data for future data collection editions (e.g., TYNDP 2028) in the absence of a new NECP to be published between now (when the TYNDP 2026 data collection is happening) and the TYNDP 2028 data collection, are shown in [Figure 7](#).

For future data collection editions (e.g. TYNDP 2028), on which documents do you intend to rely on to provide revised central scenario estimates to the ENTSOs, as long as no new NECP will have been published since the TYNDP 2026 data collection happened?



**Figure 7 – Alternative data sources for future data collection editions (in absence of up-to-date NECP)<sup>37</sup>.**  
**Source: Artelys’ survey to electricity and gas TSOs**

The topic is also in the radar screen of the SRG. Although the SRG members have not yet reached a consensus on how the problem should be tackled, they all agree that the data supplied by the TSOs for the TYNDP 2028 data collection must not be four years old but should be as up to date as possible.

An option could be to not update the assumptions derived from the national targets in the absence of major updates on the national targets (while maintaining the current scenario frequency). This

<sup>37</sup> NECPs are EU-mandated and legally enforceable (with Commission oversight), while National Strategies are voluntary and nationally driven, sometimes extending beyond NECP timelines or sectors.

approach would be in line with the requirement that the central scenarios should be driven by the (medium-term) national targets rather than by short-term trends. In intermediate updates of the central scenario (i.e., between two NECP editions), national assumptions could still be updated in order to reflect major updates of national or EU energy policies that might occur between two NECP cycles (e.g., new EU policy targets, important change of energy/climate strategy at national level). However, all the modifications of such intermediate updates would have to be made transparent and justified (as described in [Recommendation 3](#)) and validated by the NRAs (as described in [Recommendation 6](#)). It should be further discussed if this alternative option would be also applicable to ERAA, given its objective to assess the medium-term adequacy, or only to TYNDP, given the more long-term nature of this assessment.

Reducing the frequency of scenario development (e.g. having TYNDP scenarios only developed every five years), does not seem appropriate to us, as it would create too much discontinuity in the cycles, and could lead to a loss of expertise in the entities in charge of developing the scenarios, which would greatly complicate the development of new scenarios. Moreover, it could rise the problem of undermining the credibility of the scenarios (notably in situations where national targets have become outdated, but that no more recent and relevant targets are published). For these two reasons, the authors of this report do not believe that reducing the frequency of the scenarios would support the process.

On the other hand, one NRA reported that the NECP frequency could also be higher than every five years<sup>38</sup>. In our view, a significant reduction of the NECP frequency (e.g. every two years) would be difficult to implement given the complexity of developing NECPs. However, increasing the frequency of the NECPs from 5- to 4-year cycles, in order to have updated NECPs every two TYNDP cycles, could be explored.

---

<sup>38</sup> Source: Artelys' survey to NRAs

#### Recommendation 4 – Update of ERAA and TYNDP scenarios in the absence of new NECPs

The question of how the national data provided by the TSOs should be updated in the absence of new NECP or national targets could be critical for the upcoming scenarios building cycles (e.g., TYNDP 2028). Discussions on this topic between Artelys and different stakeholders during the present project revealed significant differences of opinions. For these reasons, discussions on this topic should be organised in a timely manner to align the views and define a unified approach between Member States.

A lack of anticipation or coordination on this issue could lead to heterogeneous choices being made by TSOs of different MSs, thereby undermining the coherence and reliability of the scenarios.

Among the different options described above, the most appropriate one is in our view to maintain a scenario creation cycle at least every two years (as is currently the case for the TYNDP), and to define a clear framework on how TSOs should update the values:

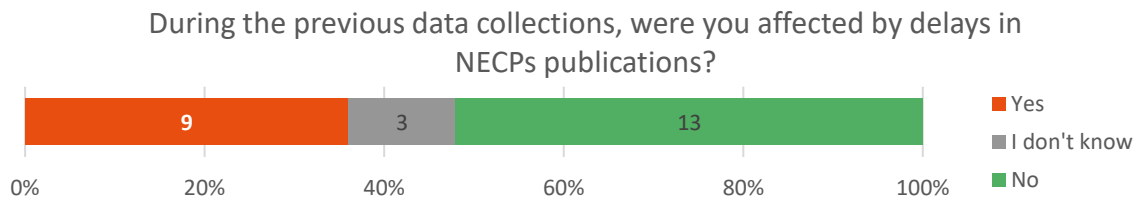
- | An option could be not to update the national assumptions unless major updates of national energy policies have occurred. In order to ensure consistency across Member States, “major update of national energy policy” would have to be further defined (e.g. is it only when enshrined in law, or can other situations also be considered?). All the modifications of such intermediate updates would have to be made transparent and justified (as described in [Recommendation 3](#)) and validated by the NRA (as described in [Recommendation 6](#)).
- | NECP Progress Reports (if available) could also be used as an alternative source.

Other assumptions than the national assumptions provided by the TSOs (e.g. commodity and carbon prices, extra-EU hydrogen prices and potentials etc.), as well as modelling approaches could still be updated in these intermediate cycles. However, to ensure the scenarios approach is consistent across cycles, the authors of this report also recommend the methodology for developing scenarios to remain relatively stable (e.g., for a period of five years). With a stable scenario development framework, it becomes easier to adapt the data and assumptions where needed. This approach would be similar to the one being applied for the CBA methodology, where the main building blocks remain stable across TYNDP cycles.

Finally, ERAA frequency could be changed from an annual basis to a biennial cycle to align it with the TYNDP (see [Recommendation 9](#)), and increasing the frequency of the NECPs from 5- to 4-year cycles, could be considered, in order to have updated NECPs every two TYNDP cycles.

In addition to the gaps between the theoretical publication schedules for NECPs and the data collection dates for TYNDP and ERAA cycles, frequent delays in the publication of NECPs complicate the task of providing the data for TSOs.

Among the respondents to the questionnaire, 9 TSOs (from 6 distinct countries) reported having been affected by delays in NECPs publications during the previous data collections cycles, while 13 TSOs (from 10 distinct countries) reported not having been impacted by such delays.



**Figure 8 – Delays in NECPs publications.** Source: Artelys’ survey to electricity and gas TSOs

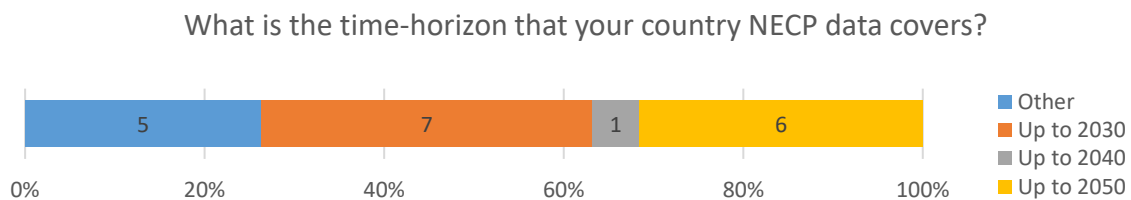
Although the TYNDP 2024 was a specific case, since the data collection was completed prior to the publication of the draft updated NECPs, this result indicates that delays in the NECPs publication can potentially represent a bottleneck in the overall scenario-building process.

More generally, TSO delays in data submission is identified as one of the primary bottlenecks in the overall scenario building process<sup>39</sup>. It should nevertheless be noted out that delays in NECPs publication is not the only reason of TSOs’ delay. TSOs’ delays can also be explained with other reasons such as internal coordination or capacity challenges within TSO organisations.

### iii. TYNDP and ERAA horizons are not always covered by the NECPs

Another important aspect, in terms of data requirements, is the time-horizon and time-granularity. First, the NECPs can present differences in those terms, meaning not all the NECPs provide data for the same years and with the same time-granularity. Second, it can happen that the time-granularity requested by the ENTSO-E and ENTSOG is not present in the majority of the NECPs.

The data time-horizon, provided in the different NECPs, is shown in [Figure 9](#).



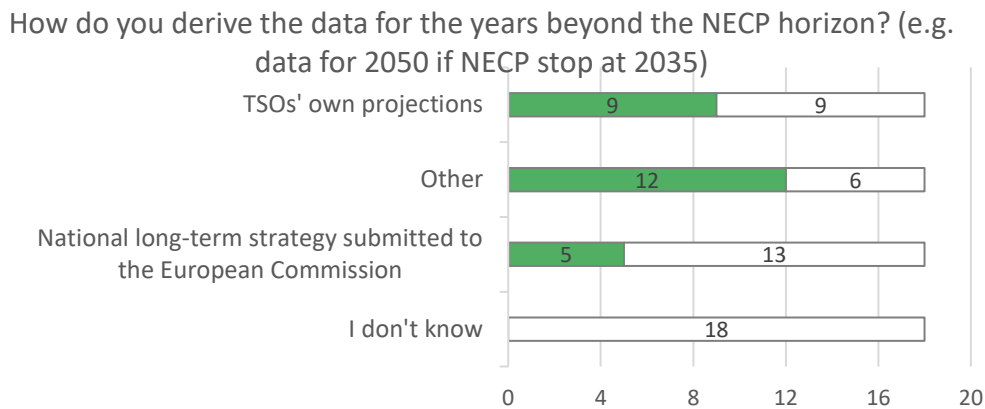
**Figure 9 – NECPs’ time-horizon<sup>40</sup>.** Source: Artelys’ survey to electricity and gas TSOs

All of the TSOs who selected “Others” explained that the NECP of their country mainly covers the period 2021-2030 but also includes some trajectories until 2040 and/or 2050. The level of the information after 2030 is however often less detailed than on the 2021-2030 period.

The sources of the data used by TSOs for years which go beyond the time horizon covered in the NECPs is presented in [Figure 10](#). Some TSO used a combination of the options.

<sup>39</sup> Interview between Artelys and ENTSO-E.

<sup>40</sup> This question was asked to both electricity and gas TSOs. For the countries for which several companies replied, their answers have been compared, merged and counted as 1 on the graph above (the sum of the numbers on the bars equals to the number of distinct countries for which at least one TSO answered the survey – 19).

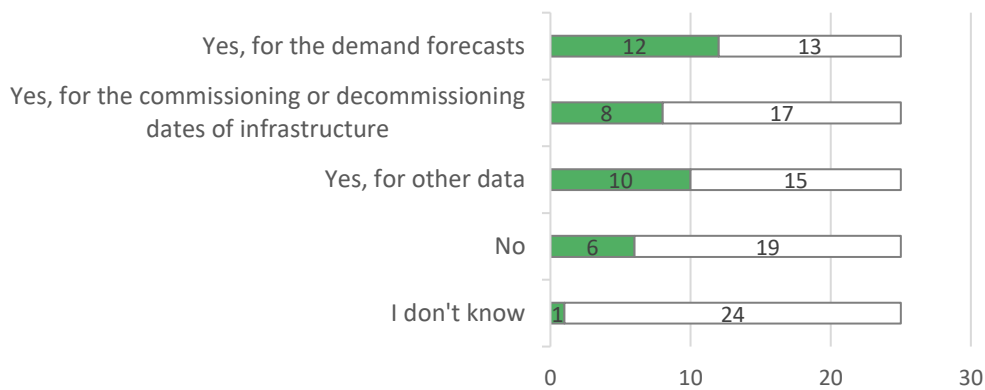


**Figure 10 – Source of data for years which goes beyond the NECP's time-horizon.**  
**Source:** Artelys' survey to electricity and gas TSOs

Within this horizon, the time-granularity of the data also varies between the countries. Most of the TSOs (13 out of 25 respondents, from 10 distinct countries) reported that the granularity of the data depends on the type of data (e.g. data reported for every intermediate year on some graphs and only every five years for other graphs) or from the horizon (e.g. data is reported for every year until 2030, and then every 5 or 10 years until 2040 or 2050). Only two TSOs (out of the 25 respondents), from two distinct countries, reported having access to the values of the NECP for every intermediate year.

The input parameters for which ENTSO-E and ENTSOG require a time-granularity which is not present in the NECPs is reported on [Figure 11](#).

Within the time frame covered by the NECPs, do you have additional assumptions to provide values to the ENTSOs more time-granular than the data available in the NECPs



**Figure 11 – Assumptions for providing more time-granular data.** **Source:** Artelys' survey to electricity and gas TSOs

Besides demand forecast and commissioning and decommissioning dates of infrastructure, some TSOs reported the need for additional assumptions for generation timeseries, hydro inflows, macro-economic demand forecast, hydrogen imports and electricity forecasted generation capacities (thermal units commissioning, based on CRM, offshore wind forecast updated planning, other RES forecasts, and nuclear when extensions have been decided by government but are not yet reflected in NECPs).

The most common methodologies/sources used by TSOs to increase the available time-granularity of specific input parameters are listed below:

- | Linear interpolation
- | National Network Development Plans (NDPs)
- | TSO and DSO assumptions
- | Additional forecasting factors (e.g., consideration of GDP forecasts, electricity efficiency, and electric vehicle and heat pump consumption projections).

### **Recommendation 5 – Mismatch between the time-horizon in the NECPs and the needs for TYNDP and ERAA scenario building**

To address the key data-related challenges in the joint scenario development process due to the mismatch between the time-horizon in the NECPs and the needs of scenario-building exercises of TYNDP and ERAA, the following solutions could be considered:

- | Extend time horizon covered by NECPs, by amending the Governance Regulation, which will need to be updated in the coming years to adapt it to post-2030 objectives<sup>41</sup>.
- | Require clearer transparency and traceability in cases where NECPs do not provide sufficient data coverage, and TSOs complement the missing inputs using their own assumptions. These additional data should be clearly labelled as non-NECP-based and should be traceable and justified (as described in [Recommendation 3](#)). They should also be subject to validation by NRAs (as described in [Recommendation 6](#)), besides the normal public consultation.
- | Update ACER TYNDP Scenarios Guidelines to provide clarity on the way scenarios should be built when all NECPs do not cover all the required time horizons.
  - A possible approach (close to the current process) is to consider the long-term national targets in the Member States when they are defined. However, ACER TYNDP Scenarios Guidelines should still provide more clarity on the way TSOs whose NECPs do not cover long-term horizons should report information to ENTSO-E and ENTSO-G. Long-term projections (e.g., for 2050) being uncertain by nature, guidance by ACER will facilitate the validation by NRAs (as described in [Recommendation 6](#)) of the TSO-provided datasets for the time horizons not covered by NECPs.
  - Another approach could be to limit the use of NECP data to the regulated 10-year horizon<sup>42</sup>, and to ignore the long-term national objectives of Member States which define it. This choice would ensure homogeneity between Member States, but would create greater distance between TYNDP and national scenarios.

---

<sup>41</sup> As the 2040 GHG reduction target should soon be agreed upon, it can be expected that the Governance Regulation will be updated to ensure all NECPs cover 2040, which is not currently the case.

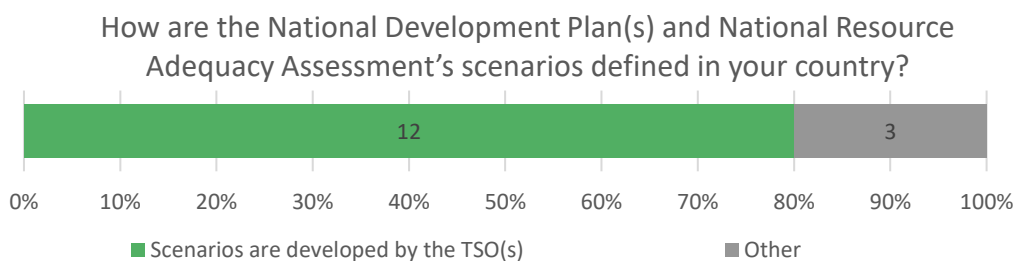
<sup>42</sup> Given that NECPs are legally required to cover only a 10-year outlook, it may be advisable to use and strictly adhere to NECPs within that timeframe.

This guidance could take the form of e.g. methods and parameters to be used for demand and capacity mix projections, commodity prices, etc. For example, long-term scenarios could rely on a centralised modelling approach, based on agreed EU targets.

iv. National Development Plans and Resource Adequacy Assessment are often used as a source to provide the data for TYNDP and ERAA scenarios.

In case of non-utilisation of the NECPs, the National Development Plans (NDP) and National Resource Adequacy Assessment (NRAA) are frequently cited as an alternative source.

The utilisation of this source is facilitated by the fact that the TSOs are responsible for developing these national scenarios in most countries, as displayed on the figure below.



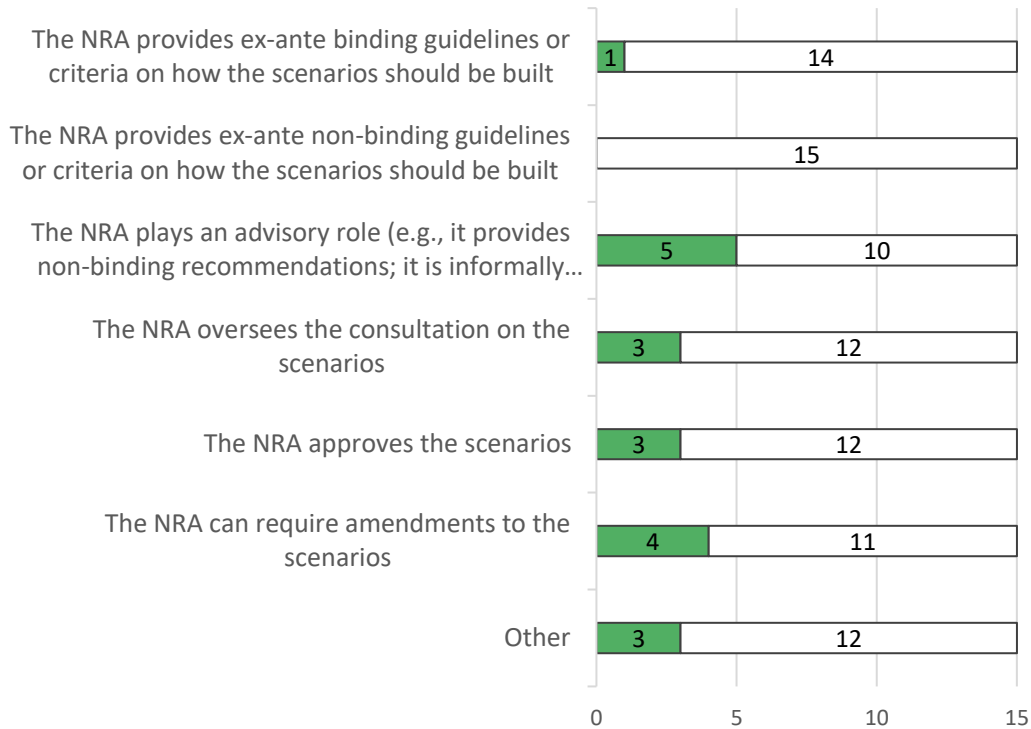
**Figure 12 – Entity in charge of developing National Development Plans and National Resource Adequacy Assessment's scenarios. Source: Artelys' survey to NRAs**

Among the three respondents who answered "Other", the TSO is always in charge of developing one of the two scenarios (NRAA and NDP):

- | In two situations, the TSO is still in charge of the NDP, while the NRAA is either developed by the NRA or currently not developed at all. .
- | Alternatively,, the Planning Agency is in charge of the development of the NDP scenarios, while the scenarios are approved by the government (with the consultation of the NRA) and TSOs are in charge of the NRAA.

Even though these scenarios are rarely developed by the NRAs themselves (only one NRA out of the 15 respondents to the survey reported it, and only for the NRAA), NRAs still can play a crucial role in the development of these national scenarios, as displayed on the figure below.

### What is the role of the NRA [in the development of the NRAA and NDP scenarios] ?

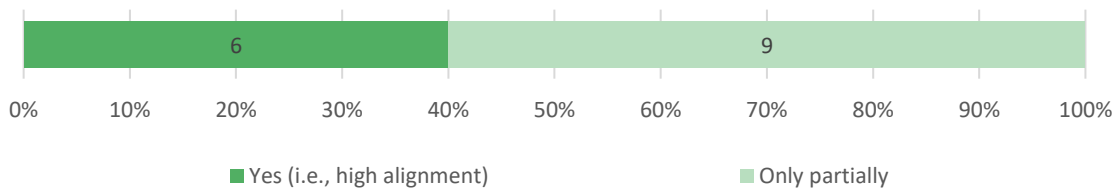


**Figure 13 – Role played by the NRAs in the NRAA and NDP building process. (each NRA ticked at least one box)**  
**Source: Artelys’ survey to NRAs**

Among the respondents who answered “Other”, two NRAs reported being specifically in charge of verifying the assumptions and scenario building process of the NDPs. One NRA mentioned that its role was only legally established for the NDP, but not for NRAA. In this case, the NRA still participates in workshop organised by the TSO on the NRAA, but only in an informal manner.

In all countries, the NRAAs and NDPs are always at least partially aligned with the NECPs (never totally misaligned), as displayed on the figure below. Therefore, relying on the NDPs and/or NRAAs when the NECPs do not provide a sufficient level of detail may be a reasonable approach. However, as emphasised in our [Recommendation 6](#), the authors of this report propose that NRAs be tasked with scrutinising the datasets shared by TSOs with ENTSO-E and ENTSOG, with a specific focus on deviations with respect to NECPs and provision of assumptions where NECPs are incomplete.

### Are the scenarios used in your country National Development Plan(s) and/or your country National Adequacy Assessment aligned with your country NECP(s)?



**Figure 14 – Level of alignment between NRAAs/NDPs and NECPs. Source: Artelys’ survey to NRAs**

When only partially aligned, two NRAs reported that the scenarios are only aligned with the NECPs in terms of basic assumptions (e.g. laws, energy & climate high level objectives or renewables development). Other deviations between NDPs/NRAAs and NECPs were reported by NRAs in terms of:

- | **Update frequency:** two NRAs reported that NDPs/NRAAs are updated more frequently (and thus are often more up to date). On the opposite end of the spectrum, another NRA reported that its gas NDP hasn't been updated since 2008 (and is therefore out-dated).
- | **Horizons covered:** one NRA explained that the partial misalignment between the two scenarios and the NECP is due to the fact that the NECP does not cover the period beyond 2030, whereas the NRAA runs up to 2035.
- | **Number of scenarios, variants and sensitivities:** two NRA reported that the scenarios developed by the TSOs contain a group of scenarios representing a different macroeconomic global context, or sensitivity analysis (e.g. on the deployment speed of batteries up to 2030).

Finally, it should be noted that the relation between national scenarios and ERAA/TYNDP scenario is bidirectional: not only are national scenarios often used as a source by the TSOs to define ERAA and TYNDP national input data, but ERAA and TYNDP scenarios are also frequently used as a data source for the construction of the national scenarios (presumably not for assumption on the main country studied, but rather for the assumption on neighbouring countries). This highlights a positive side-effect of the ERAA and TYNDP scenarios: to serve as a platform for the alignment of assumptions between national TSOs by exchanging their respective national projections for the construction of their national scenarios.

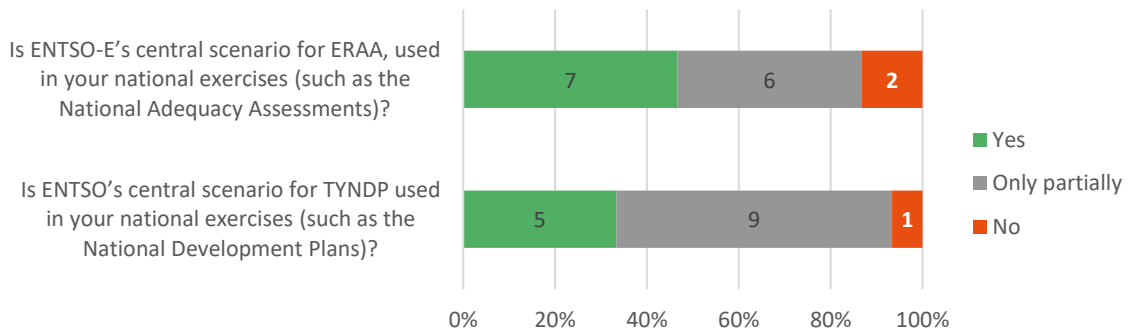


Figure 15 – Utilisation of ERAA and TYNDP scenarios in the NDPs and NRAAs building processes

### 1.2.2.3 Validation and consolidation of the data provided by the national TSOs

All along with the data collection process from the national TSOs, different verifications and checks on the data are performed. The data validation can take several forms depending on the countries.

#### Alignment between gas and electricity TSOs within each country

During the data collection process, around 70% of the TSOs (18 out of 25 respondents) reported coordinating with other TSOs from the same country (e.g. in charge of other energy carriers). Eight TSOs reporting that aligning with the other TSO of the country was more challenging on the long-term

horizons (both because there is more uncertainty and more room for interpretation at these horizons, combined with the fact that NECPs are often less precise on the long-term horizons). Finally, some TSOs in countries with several TSOs for the same energy carrier (for instance between the German gas TSOs) reported the existence of a national working group being formed in order to discuss their differences in visions and understanding.

While most of the respondents reported that the differences in views between electricity and gas TSOs were small or possible to reconcile, some still mentioned a stronger barrier for common alignment which required more efforts in terms of strategic negotiations and willingness to compromise to the extent possible.

In addition, TSOs should also coordinate with their respective DSOs, in ensure consistency between their assumptions (both for the ERAA/TYNDDP scenario building are for their Network Development Plan) and the assumptions of the Distribution Network Development Plans.

### Alignment with TSOs from neighbouring countries

As illustrated on the figure below, the majority of TSOs coordinate with TSOs from the neighbouring countries, at least when submitting interconnection capacities. This is particularly true for the electricity TSOs, for which the 100% of the respondents declare coordinating with TSOs from neighbouring countries. This high score is also due to the TSO cross-validation process set by ENTSO-E, which consists in having each national TSO checking the national values provided by some of their neighbouring countries.

In the data collection process, do you coordinate with TSOs from neighbouring countries?

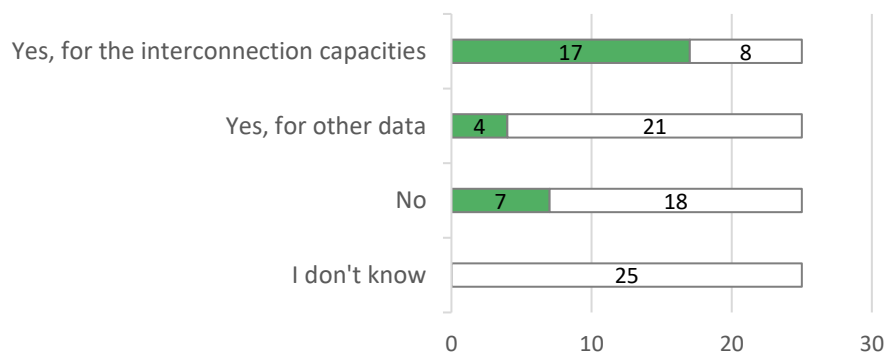


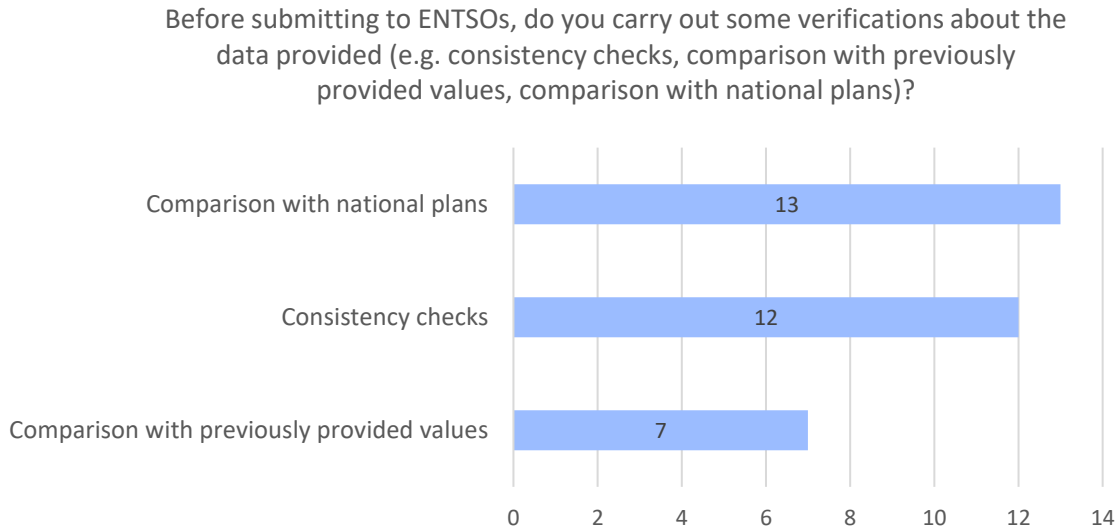
Figure 16 – Alignment with TSOs from neighbouring countries. [Source: Artelys’ survey to electricity and gas TSOs](#)

In case of misalignments between TSOs, the different processes, followed by the TSOs, for the interaction with other neighbouring TSOs, especially in case of different visions, are shown below:

- | Email and meeting-based coordination between TSOs (≈ 70-80%)
- | Data validation or harmonisation process through ENTSO-E framework (≈ 20-30%): If there is misalignment between the values and in case an agreement cannot be reached, the matter is dealt with under the ENTSO-E framework.

**TSOs’ internal validation process before sending data to ENTSO-E and ENTSG**

95% of TSOs (who participated to the questionnaire) reported carrying out internal verifications about the data provided, before submitting it to the ENTSO-E and ENTSG. The TSOs were asked to describe (in a free text question) the methods used for these consistency checks. The methods used and their popularity, among the TSOs are shown in [Figure 17](#).



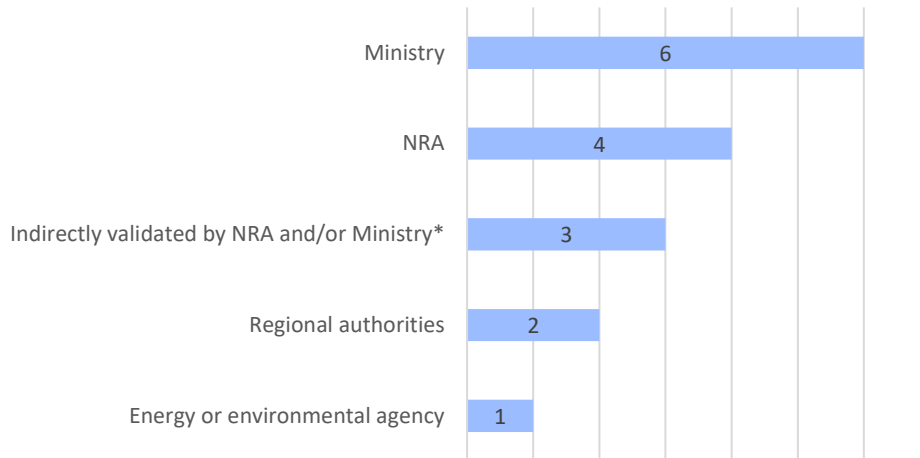
**Figure 17 – Methods of data verification. Source: Artelys’ survey to electricity and gas TSOs**

Several TSOs also pointed out that the discussion with other TSOs (as described above) and with other national stakeholders (as described below) support the validation of the data provided to the ENTSO-E and ENTSG.

**Validation of the data with external national stakeholders**

In addition to internal verifications, some TSOs report seeking verification of the details from external entities as well. However, it is not clear whether the verification is officially reported to ENTSO-E and ENTSG or not.

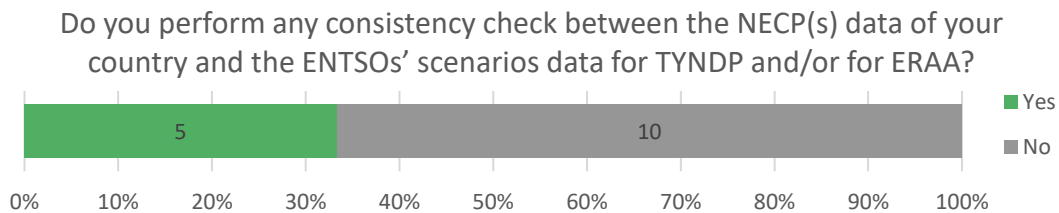
Before submitting to ENTSOs, do you validate the data with the NRAs or with other entites (please specify)



*\*Indirectly validated by NRA and/or Ministry: values taken from national development plans and/or national adequacy assumptions. The assumptions of the national plans have been validated by the NRA and/or Ministry during the national plan building process. Therefore, the TSOs report no additional need for validation from NRA and/or Ministry.*

**Figure 18 – TSOs' data validation with other national stakeholders.** [Source: Artelys' survey to electricity and gas TSOs](#)

Consistently with the above results, Artelys' survey among NRAs confirms that consistent results on the checks currently carried out by the NRAs are infrequent. Out of the 15 NRAs who answered the survey, only 5<sup>43</sup> declared performing consistency checks on the data submitted by their TSO(s) for TYNDP and ERAA:



**Figure 19 – Number of NRAs performing consistency checks between the NECP data and TYNDP/ERAA assumptions.** [Source: Artelys' survey to NRAs](#)

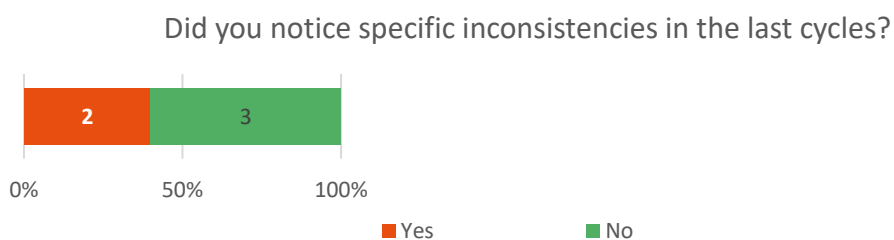
These five NRAs reported to check (in free text answers):

- | Generation per technology type (future and actual fleet), notably CCGT, hydro, solar, wind, batteries, cogeneration
- | Demand assumptions

<sup>43</sup> Out of the five NRAs declaring performing consistency checks on the data submitted by their TSO(s) for TYNDP and ERAA, one declared that these checks were only carried out by the electricity division and not by the gas division.

- | Renewable load coverage ratio
- | Flexibility potential including storage technologies and/or demand-side response assumptions
- | One NRA specifically reported checking time series (and not only annual values).

Out of these five NRAs, two declared having noticed specific inconsistencies in the last cycles.



**Figure 20 – Inconsistencies between NECPs and data submitted by national TSOs to ENTSO-E and ENTSG noticed by NRAs. Source: Artelys’ survey to NRAs**

One of the two NRAs specified that the inconsistencies were on demand assumptions, wind projections and the renewable load coverage ratio, and that these deviations from the NECPs are neither explained nor addressed by the TSOs. For instance, this NRA reported that the demand developments are overestimated in the scenarios, and that no structural explanation of this demand increase and representation of the demand segments are provided. It is important to bear in mind that, based on the survey conducted with TSOs, it emerged that deviations from NECP values do not always occur due to a lack of information in the NECPs. In some cases, even when NECPs contain the required data, TSOs decide to deviate from it, relying on other sources. This is done for reasons already explained earlier, such as perceived higher accuracy, more recent data availability, or alignment with national strategies or internal planning assumptions.

The second NRA that reported having noticed inconsistencies did not specifically mention which inconsistencies they observed, but explained that these inconsistencies were due to a lack of precise information in the NECP:

- | For a number of relevant data points, the NECP provides indicative targets rather than definitive trajectories for demand and installed capacities, due to political uncertainty (and the fact that the national energy law was not adopted when the NECP was submitted).
- | Some targets in the NECPs are defined in terms of growth pace, which can lead to different ending points depending on the starting point of the study.
- | Some of the ERAA’s horizons are not detailed in the NECPs.

These observations confirm issues with the NECPs reported by the TSOs (see section [1.2.2.2 Sources used by the national TSOs and difficulties encountered](#)).

One of the three NRAs who replied not having noticed inconsistencies between NECPs and TYNDP/ERAA assumptions still reported some doubts about the way hydro specificities are reported.

### **Recommendation 6 – Systematic scrutiny and validation by the NRAs of the input data provided by the TSOs**

In order to enhance the transparency and reliability of the data collection process, ACER TYNDP Scenarios Guidelines could be amended to request for an intermediate validation layer of national data between TSOs and ENTSO-E and ENTSG. The designated entity would be responsible for reviewing and validating input parameters before they are integrated into the overall process, including the analysis of the reasons why deviations between NECPs have been introduced by TSOs.

This recommendation requires [Recommendation 3](#), which states that TSOs must clearly report all the deviations performed compared to the NECPs, to be implemented.

The validation of the compliance of national scenario input data provided by the TSOs NECPs and national strategies is a difficult task, which require accurate and up-to-date knowledge of the energy context of each Member State. Moreover, this process is also difficult to automate for all countries (although improvements could be made in this area<sup>44</sup>). Therefore, the entity tasked for this validation could be:

- | Best solution: NRAs seem to be in the best position to have the responsibility for checking and validating the compliance of the data provided by the TSOs with the national plans and targets.
- | Fallback solution: As an alternative, national responsible ministries could also play that role. However, as several ministries are involved in the drafting of NECPs in some Member States, it seems that this option is less desirable compared to the one where NRAs are responsible.

This process is already implemented in some Member States but should be extended to all Member States.

Furthermore, a single template could be defined and used by all TSOs and NRAs for this process, in order to ensure greater transparency of the deviations from the identified NECP input parameters and to enable cooperation.

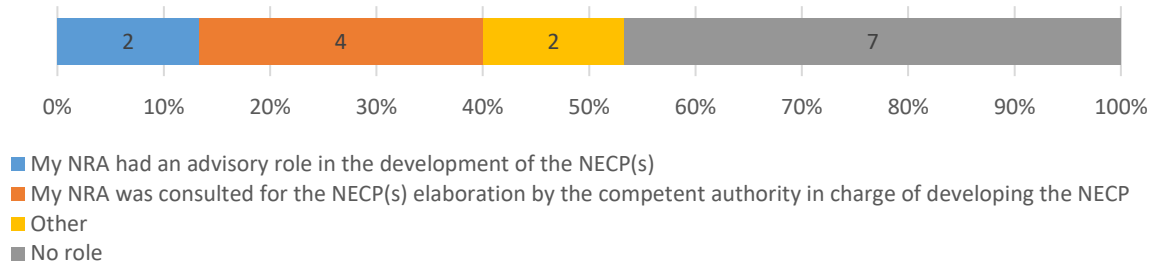
This additional oversight mechanism can help mitigate risks related to the margin of interpretation left by NECPs and limit risks of conflicts of interest (see section [1.2.4 Risk of conflict of interest](#)), ensuring greater consistency and credibility in the scenario-building processes.

This recommendation is also supported by the fact that half of the NRAs who answered the survey declared being involved in the preparation of the NECPs, as displayed on the figure below.

---

<sup>44</sup> See for instance Artelys' [Recommendation 2](#) to extend the use of Annex 1 Part 2 template for the publication of the NECPs by the Member States, in section 1.2.3 of the present report.

What role does your NRA play in the preparation of the NECP(s) in your country?



**Figure 21 – Involvement of the NRAs in the preparation of the NECPs. Source: Artelys’ survey to NRAs**

The two NRAs who responded “Other” explained either having contributed to the consultation process (workshop and task forces organised by the government), or having contributed to the preparation of the parliamentary discussions on the NECP update.

### Consistency checks carried out by the ENTSO-E and ENTSOG and iterations between the ENTSO-E and ENTSOG and national TSOs

During the data collection, 76% of the TSOs reported to carry out iterations on the data with ENTSO-E and ENTSOG during the data collection.

As a confirmation of this, during the exchanges between Artelys and ENTSO-E and ENTSOG, the latter emphasised that the data collection process involves continuous interaction with TSOs. For example, ENTSOG highlighted a case in which a TSO identified a discrepancy in the reported biomethane value, which differed from the original data which was submitted. The error was traced back to ENTSOG’s processing phase. This example was used by ENTSOG to underscore the importance of a continuous review process between ENTSO-E and ENTSOG and TSOs, facilitated through regular meetings attended by approximately 70–75% of TSOs.

However, ENTSO-E and ENTSOG clarified not carrying detailed alignment checks on the values submitted by the TSOs with the NECPs besides the detection of outliers. In particular, the responsibility of providing NECP-compliant values lies solely with the national TSOs. ENTSO-E and ENTSOG justify not double checking the values provided by the TSOs with those present in the NECPs by a lack of time and resources for it. A replicable approach for ACER to verify the compliance with the NECPs is proposed in section [1.2.3](#) below.

### Public consultation, SRG and stakeholders’ roundtables

Public consultation is an important milestone, both in the TYNDP and the ERAA processes. The public consultation or call for evidence (as defined in ERAA) happens right after the end of the data collection, with the objective of gathering evidence-based feedback on the input data and assumptions from various stakeholders.

For TYNDP 2026, the public consultation on input parameters started on the 16<sup>th</sup> of June and finished on the 14<sup>th</sup> of July. It is input to underline that some elements are only provided for information purposes, including: ETM Dashboards illustrating energy demand breakdowns by carrier and sector, ETM Links including country and sector specific energy demand inputs, SMR and pyrolysis capacities, PEMMDB 2.5. illustrating electricity generation and flexibility capacities, and additional data collection supplementary supply and demand datasets<sup>45</sup>.

For ERAA 2023, ENTSO-E published the preliminary input dataset for stakeholder validation on 14 March 2023. A call for evidence to gather stakeholder feedback was launched on the same day and remained open for about twenty days. The call for evidence aims at providing feedback on six domains: PEMMDB national estimates, net transfer capacities, climate data, list of CNECs<sup>46</sup>, demand dataset, and fuel and carbon price trajectory. The public consultation on ERAA results started on 18<sup>th</sup> December 2023 and closed on the 31<sup>st</sup> of January 2024. Following this public consultation, ENTSO-E has published the feedback received to the consultation, as well as ENTSO-E's answers to these feedback<sup>47</sup>.

For TYNDP 2024, ENTSO-E and ENTSG published a Consultation Summary Report<sup>48</sup>, summarising the answers received to the public consultation as well responses to that feedback explaining how the input was considered, and whether (and why) it was or wasn't integrated into the final methodology or assumptions. In addition, ENTSO-E and ENTSG also made available the detail of all answers received to the public consultation<sup>49</sup>.

### **Recommendation 7 – Publication consultation on input data**

All inputs used in the scenario development process should be open to public consultation. Making the underlying assumptions and datasets transparent from the beginning is essential for improving the overall quality of both the TYNDP and ERAA scenarios.

The publication of the feedback received to public consultation and/or call for evidence, as well as ENTSO-E and/or ENTSG's answers to the feedback and explanation of the way feedback will be taken into account is a good practice that should be continued and strengthened.

Similarly, publishing the questions received during webinars and ENTSGs answers<sup>50</sup> is a good practice to be continued.

---

<sup>45</sup> [Link](#)

<sup>46</sup> CNECs (Critical Network Elements and Contingencies): These are specific network elements (like transmission lines or transformers) combined with relevant contingencies (such as potential failures or outages) that are monitored to ensure the stability and reliability of the power grid.

<sup>47</sup> Accessible through the public consultation page: [Link](#)

<sup>48</sup> [Link](#)

<sup>49</sup> [Link](#)

In addition to the public consultation, the TYNDP 2024 edition introduced, for the first time, and TYNDP 2026 confirmed them, stakeholder roundtables. These roundtables bring together a smaller group of experts to engage in more targeted discussions that go beyond the general feedback typically received through the public consultation process. The purpose of forming these focused expert groups is to facilitate in-depth dialogue on specific aspects of the scenario-building process, thereby enhancing both the efficiency and effectiveness of stakeholder engagement. In general, public consultations (TYNDP only) are followed by the organisation of stakeholder roundtables to further explore key issues and refine inputs.

During the 2024 version of the TYNDP, a new Stakeholder Reference Group (SRG) was created for the first time. The creation is based on ACER TYNDP Scenarios Guidelines. The Scenarios SRG aims at providing timely, expert input to the development of scenarios by ENTSOE and ENTSOG in accordance with the scenario development timeline. It is not meant to replace other stakeholder engagement methods (including public consultations, stakeholder events and bilateral discussions) but to complement them. In TYNDP 2024, a call for interested candidates was launched on 5 May 2023 with the deadline of 5 June 2023. Stakeholders from categories such as associations involved in the gas and electricity market, heating and cooling stakeholders, CCS & CCUS stakeholders, demand-side operations, etc. were invited to apply. The SRG operates separately from the Scenario Building Team, organizing its own activities, while ENTSO-E and ENTSOG host the platform, ACER, the European Scientific Advisory Board on Climate Change and pre-ENNOH participate as observers. In TYNDP 2026, the SRG has been in place since the beginning of the process and involved throughout the process. The main contributions from the SRG for the TYNDP 2024 preliminary results are listed below:

#### | **Process Improvement**

- Advised on timelines for future cycles (e.g., earlier access to data for thorough review).
- Pushed for better data transparency

#### | **Scenario quality and comparability**

- Urged alignment with EU policy targets (e.g., GHG emissions, energy efficiency metrics) and comparability with European Commission scenarios.
- Highlighted discrepancies in historical data (e.g., heat pump adoption rates, industrial demand profiles) and recommended corrections. For example, the SRG found that the ETM model overstated heat pump adoption in 2019, underestimated district heating in Australia and Germany, etc.

#### | **Technical feedback on modelling**

- Demand-side issues
  - Critiqued unrealistic assumptions in the ETM model (e.g., heating technologies, non-residential building demands). For example, the model assumed uniform heat pump performance without accounting for unrenovated buildings with traditional radiators, as well as non-residential buildings to which were assigned arbitrary energy demands. On the hydrogen

side, the model ignored emerging technologies (e.g., pyrolysis, waste-to-hydrogen) and assumed inflexible e-fuels production.

- Proposed disaggregated hourly load profiles for heat pumps, EVs, and industrial sectors.
- Hydrogen modelling:
  - Advised updating hydrogen import price assumptions (e.g., ammonia transport costs)
- Renewables and flexibility:
  - Flagged divergences between wind capacity targets and model outputs.
  - Requested clarity on demand response and battery storage modelling.

#### | **Methodological enhancements**

- Proposed running models with multiple climate years to account for weather variability.
- Advised cross-checking results against national grid development plans (TSOs/DSOs).

#### **Data updates cut-off date**

Once the parameters are finalised and approved, TSOs are no longer permitted to modify them, except for extreme cases in which it has been shown that there would be a high impact of final results in case of not changing the parameter. Defining and respecting this cut-off date is a key and necessary element in the development of scenarios, in order to limit delays and allow modelling to proceed without having to continually take account of data updates. In some instances, TSOs have proposed amendments after the approval stage, but ENTSO-E and ENTSOG have rejected those requests<sup>51</sup>.

Finally, after public consultation and stakeholder roundtables, the ENTSO-E and ENTSOG are supposed to release the final input datasets for the TYNDP 2026.

## 1.2.3 Design of a replicable approach to verify the scenario's compliance with the NECPs

### 1.2.3.1 Introduction and preliminary recommendations

One of the main issues identified in the ERAA and the TYNDP scenario-building processes is the lack of a systematic mechanism and approach to verify the consistency between TSO-submitted data and the corresponding National Energy and Climate Plans (NECPs). Each NECP consists of approximately 100 to 150 pages, and considering the number of Member States, along with the fact that each NECP is written in a different national language, and with a different format, conducting a full cross-check

---

<sup>51</sup> Source: interviews between Artelys and ENTSOs.

requires a high level of effort and time. This challenge is further amplified by the strict timelines under which the ENTSO-E and ENTSOG must operate to deliver scenarios on an annual (ERAA) or biennial (TYNDP) basis.

As acknowledged by the ENTSO-E and ENTSOG themselves during interviews, a comprehensive compliance check against the NECPs is currently not feasible<sup>52</sup>, which means that ENTSO-E and ENTSOG must place full trust in the TSOs to accurately report values sourced from their respective NECPs. Nevertheless, the SRG reported performing consistency checks between the NECPs and the values provided by TSOs on some specific aspects.

In principle, the Excel template of Annex 1 part 2<sup>53</sup> of the NECPs, which invites Member States to report key variables, such as final energy consumption, in the form of time series<sup>54</sup>, should facilitate comparison of values provided by National TSOs with NECPs. It should be borne in mind that it only gives information about the data parameters present in the NECPs, meaning that possible gaps cannot be checked in this way. However, because Member States are encouraged (not required) to use this template alongside the official submission, the template is not systematically used, and when used, not systematically fully completed or not systematically published in an Excel format (sometime, only the pdf version is available), which complicates the analysis.

DG ENER noted that, while there was a good level of utilisation of this Excel template in the early phases following the introduction of the Governance Regulation (related to the annex), Member States have progressively become less consistent in using this tool. As a result, for the construction of the Commission's Reference scenario (which should be based on the NECPs), DG ENER now holds bilateral meetings with each Member State to validate data interpretations and ensure a mutual understanding of the reported figures. This results in a continuous feedback loop between DG ENER and Member States.

These loops contribute to improving the accuracy and completeness of the way the NECPs are integrated into the European Commission's Reference Scenario building process, but they occur outside the ENTSO-E and ENTSOG' current workflow, leading to a missed opportunity for alignment across processes.

---

<sup>52</sup> ENTSO-E and ENTSOG do have some data quality checks in place to detect inconsistent values and outliers in the data reported by the TSOs. However, these data quality checks do not enable to detect small deviations from the NECPs.

<sup>53</sup> Example of Annex 1 for Denmark: [Link](#)

<sup>54</sup> Annual timeseries with one value per year.

### Recommendation 8 – In-depth collaboration with the European Commission on the consistency of ERAA and TYNDP scenarios with NECPs

In the absence of progress on the uniformity of the NECP formats among Member States, stronger collaboration channels between the ENTSO-E and ENTSO-G, the European Commission (potentially through the JRC) and ACER should be established to validate the scenarios' compliance with the NECPs.

- | Best solution: For future TYNDP cycles (during which the European Commission's new Reference Scenario will be available), a systematic comparison between the EU Reference Scenario and the new TYNDP/ERAA scenarios would also enable to detect deviations (while recognising that some of these deviations could be justified (1) by differences in the models used, and (2) by potential differences between the set of measures considered in NECPs and the ones integrated in the Reference Scenario).
- | Fallback solution: If the publication of the excel file in Annex 1 part 2 of the NECPs becomes mandatory for Member States (as proposed in [Recommendation 2](#)), the SRG or any other relevant entity could check the consistency between the TSOs' submitted data and the NECP parameters.

#### 1.2.3.2 Design of a replicable approach

The approach proposed below can be implemented to investigate the compliance of the data provided by the TSOs with the NECPs. This approach has been designed to be pragmatic and replicable.

##### Step 1 – initial screening

The first step of the approach, data compiled by a number of external organisations could be used. These entities have developed intuitive platforms and datasets that collect and visualise energy data, both from NECPs and other sources.

The goal of this approach is not to replace official data validation but to serve as a preliminary screening tool to identify potential discrepancies that may warrant further investigation. Below is a list of organisations providing relevant datasets, along with specific information on the type of data they offer:

- | **EMBER:** This is the primary source recommended, as it directly extracts data from NECPs and presents it in a condensed, accessible, and user-friendly format. EMBER offers an Excel-based dataset including supply, demand, and emissions data, categorised by country, sector, and energy carrier. ([Link](#))
- | **WindEurope:** Provides projections of installed wind capacity for 2030, disaggregated by country. ([Link](#))
- | **SolarPower Europe:** Offers projections of installed solar capacity for 2030, also by country. ([Link](#))
- | **CAN Europe:** Publishes forward-looking data on emissions, energy consumption, and supply, with projections extending to 2030. ([Link](#))

One may notice that members of most of these organisations are also involved in the TYNDP Stakeholder Reference Group, which opens the door to strong synergies between these validation work and the SRG's activities on TYNDP. Moreover, members of the SRG reported having already carried out some of these checks on TYNDP 2024 data, in particular on wind capacity.

The following examples are provided in the tables below:

- | An example of comparison of the electricity final energy demand (for the year 2030), between EMBER’s NECP values and TYNDP 2024 preliminary input parameters, is illustrated in [Figure 22](#) and [Figure 23](#).
- | An example of comparison of the onshore wind capacity (for year 2030), between Wind Europe 2030 scenarios and TYNDP 2024 final input parameters, is illustrated in [Figure 24](#) and [Figure 25](#).

Electricity demand comparison between the NECPs and the TYNDP 2024 values

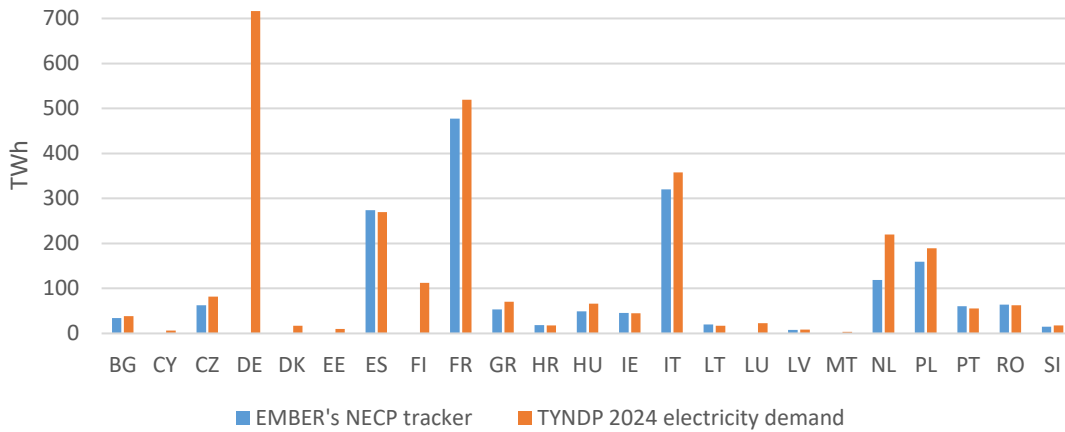


Figure 22 – Comparison between EMBER values and TYNP 2024 input data

Variation between electricity demand values from EMBER's NECP and the TYNDP 2024 values

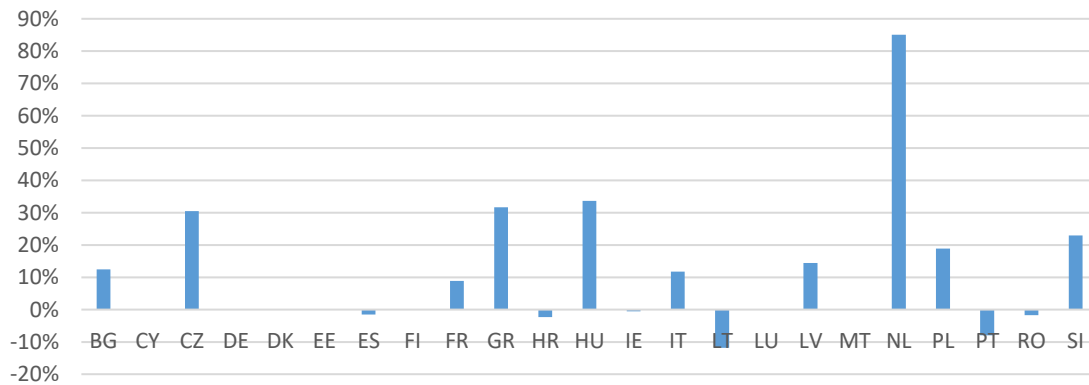


Figure 23 – Percentage variation of data comparison (EMBER’s NECP vs TYNDP 2024 input data)

### Onshore wind capacity comparison between Wind Europe scenarios and the TYNDP 2024 values

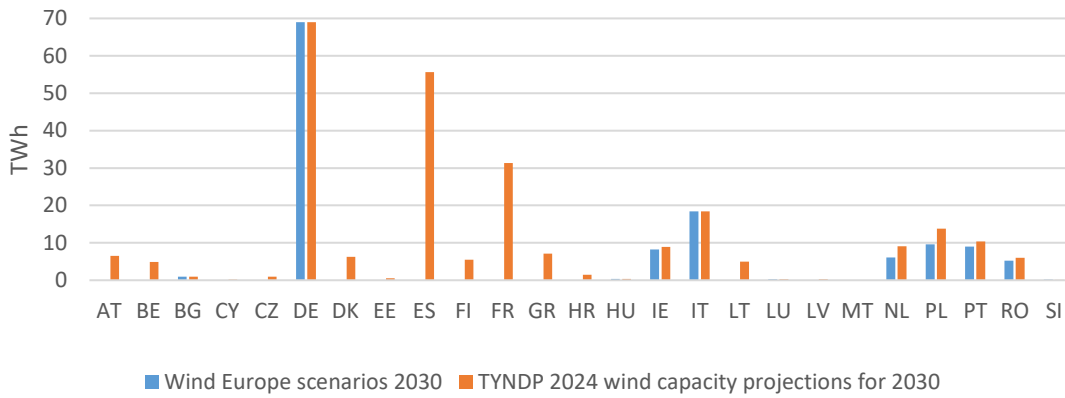


Figure 24 – Comparison between Wind Europe values and TYND 2024 input data

### Variation between onshore wind capacity from Wind Europe scenarios and the TYNDP 2024 values

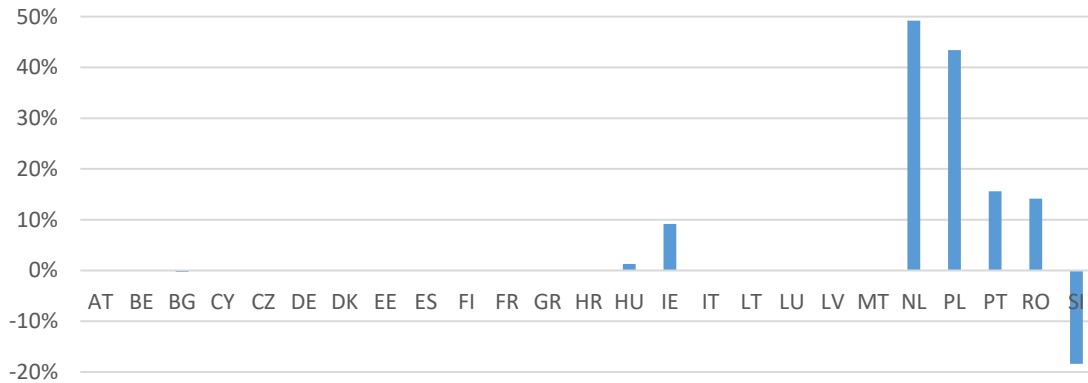


Figure 25 – Percentage variation of data comparison (Wind Europe vs TYNDP 2024 input data)

Since the data used as a counter-factual does not come from official sources, the first step is not sufficient to conclude on the non-compliance of the input assumptions of TYNDP and ERAA scenarios with NECPs. This first step should rather be seen as a way to detect potential inconsistencies (which have then to be further investigated in the second step – described below) and streamline the analysis process by focusing attention on likely candidates for more detailed review.

#### Step 2 – further investigations

The objective of the further investigation is to validate or invalidate the deviation ‘hints’ identified in step 1. To that end, the following process can be followed:

- 1. Validate that the value reported by the third-party (e.g. EMBER) is aligned with the official source of the NECPs.** To do this, the only option would be to directly identify and verify the value within the country’s NECP. If performed by ACER, this task could potentially be supported by the relevant NRAs.

**2. Validate that the scope of the value as reported in the NECP is well consistent with the value proposed for the scenarios.** The list of points to be systematically checked are:

- Do the compared values have the same unit (incl. in terms of HHV/LHV<sup>55</sup> for gas-related parameters)?
- Has the NECP been updated after the TYNDP/ERAA data collection cut-off date?
- Do the values cover the same perimeter?
  - How are islands or offgrid production/consumptions accounted?
  - How are losses, self-consumption (for consumption) and symmetrically ancillary consumption and self-production (for generation parameters) accounted?

Additional parameter-specific points can be checked to validate the comparability of the values (e.g. for wind: how is accounted offshore/onshore wind, and dedicated wind for hydrogen generation?). Further examples are provided in section 4 of the present report.

**3. Engage in bilateral discussions** either with ENTSO-E and ENTSOG or directly with the TSOs.

### 1.2.4 Risk of conflict of interest

The TYNDP and ERAA scenarios are essential building blocks feeding into studies and processes supporting decision-making related to infrastructure development (at EU and national levels) and the introduction of capacity remuneration mechanisms at national level. Therefore, the contents of the scenarios that are generated by the ENTSO-E and ENTSOG directly impacts decisions related to investments in electricity and hydrogen grids as well as in generation assets and flexibility solutions.

In our view, with regards to infrastructure planning, two key inputs – demand projections and the reference grid – play a critical role in determining infrastructure needs and cost-benefit analysis. As a result, these inputs are particularly sensitive in terms of the risk of conflicts of interest. For instance, ACER reported (in the ACER opinion on TYNDP 2024 scenarios) that the hydrogen demand appeared very optimistic..

When establishing the NT+ scenario, TSOs are expected to take NECPs into account to the extent possible, which helps mitigate the overall risk of conflict of interest associated with the data collection process.

However, the differing level of completeness of NECPs requires TSOs to partially rely on alternative sources or on their own estimates, introducing a risk of conflict of interest or arbitrariness. Additionally, in those cases in which the input parameter must be provided by both gas and electricity TSOs (for example the gas-fired power generation capacity) coordination issues, which may occur, add up to risk of conflict of interest. Since ENTSO-E and ENTSOG do not have a systematic verification

---

<sup>55</sup> HHV : Higher Heating Value; LHV: Lower Heating Value.

process in place for such estimates, they must rely solely on TSOs' self-reported data, increasing the risk of conflict of interest in the overall process. Regarding infrastructure planning, this is particularly true for the reference grid, for which assumptions are very rarely made explicit in NECPs. Furthermore, based on [Figure 2](#), it is possible to notice that DSR, SMR installed capacities and technical parameters such as yields, must-runs etc., are the ones which stands more for lack of information in the NECPs, and for which the TSOs must take their own assumptions.

Regarding adequacy assessments, the two critical inputs are projected peak demand (the peak value has a stronger impact on the results than the total annual demand) and peak capacities. Both inputs are rarely explicated in the NECPs. Nevertheless, it should be noted that the improvement developed over the last cycles (development and standardisation of the Demand Forecasting Toolbox<sup>56</sup> on the one hand, and implementation of the Economic Viability Assessment (EVA)<sup>57</sup> on the other hand) has supported uniformization of the practices among the TSOs, reducing the risk of data manipulation by TSOs.

Table 3 shows a graphical summary of the impact and risk of conflict-of-interest analysis of the input parameters mentioned in this chapter.

Input Parameter	Impact on ERAA key results	Impact on TYNDP key results	Level of detail of the NECPs	Risk of conflict of interest
Demand projections	Medium	High	High <sup>58</sup>	Medium specifically for TYNDP, cause very sensitive parameter but often precisely reported in the NECPs.
Projected peak demand	High	Low	Low	High risk for ERAA. The parameter is central in the scenarios results and the parameters is rarely explicated in the NECPs.
Projected peak capacities	High	Low	Medium	High risk for ERAA
Reference grid	Medium	High	Medium	High specifically for TYNDP.
Gas-fired power plants capacity	Medium	Medium	Medium	Generally medium.

<sup>56</sup> Further described in section 0 of this report.

<sup>57</sup> Further described in section 1.3.3.1 of this report.

<sup>58</sup> The level of detail of demand projections in the NECP is generally quite high except for hydrogen, which can be qualified as medium.

<b>Demand-side flexibilities</b>	Medium	Medium	Low	Generally medium.
<b>Other technical parameters (e.g. yields, must-runs, etc.)</b>	Medium	Medium	Low	Generally medium.
<b>SMR installed capacity</b>	<i>n.a.</i>	Low	Low	Generally medium.

Table 3 – Impact and risk of conflict of interest of specific parameters

For each of the input parameter, an explanation for the categorization in high/medium/low concerning the impact on the ERAA and TYNDP key results is provided below.

- | **Demand projections:** For ERAA, demand projections have a medium impact because they influence the simulation of aggregate demand but are often well-defined in the NECPs, reducing uncertainty. For TYNDP, the impact is high since demand projections are a very sensitive parameter that determines investment scenarios and infrastructure planning. However, their precision in NECPs makes the input quite reliable.
- | **Projected peak demand:** Projected peak demand is critical for ERAA because it determines the risk of system adequacy; however, this parameter is rarely explicitly detailed in the NECPs, increasing the risk of error. For TYNDP, the impact is low as infrastructure planning relies more on other metrics beyond peak demand alone.
- | **Projected peak capacities:** Projected peak capacities are central to ERAA to assess available capacity against peak demand, directly affecting security and reliability of supply. For TYNDP, the impact is lower because infrastructure planning considers capacity within a broader, longer-term context.
- | **Reference grid:** The reference grid is very important for TYNDP, which focuses on transmission network evolution, power flows, and congestion, all crucial for investment decisions. For ERAA, while important, the grid reference has a medium impact since adequacy evaluation relies more on overall capacities than grid details.
- | **Gas-fired power plants capacity:** Gas-fired power plant capacity influences both ERAA and TYNDP moderately, as these plants often provide system flexibility and security but are not the sole drivers in scenario models.
- | **Demand-side flexibilities:** Demand-side flexibilities are increasingly relevant. In ERAA, they help reduce demand peaks and improve adequacy; in TYNDP, they affect resource planning and investment optimization. However, NECPs often lack detailed information, leading to a medium impact rating.
- | **Other technical parameters (e.g., yields, must-runs, etc.):** Technical parameters such as yields and must-run influence dispatch simulations and availability, impacting both exercises moderately as they affect operational characteristics but are not decisive alone.
- | **SMR installed capacity:** For TYNDP, it has a low impact because SMR capacity is not a major component in current scenario models.

Whilst progress over the last scenario building cycles should be recognised, further improvements toward a reduced risk of conflict of interest could be implemented. For instance, in order to enhance the transparency and reliability of the data collection process, ACER TYNDP Scenarios Guidelines could be amended to request for an intermediate validation layer between TSOs and ENTSO-E and ENTSOG, and subsequently NRAs would be responsible for reviewing and validating input parameters (based also on the before mentioned validation review carried out by the ENTSO-E and ENTSOG) before they are integrated into the overall process, including the analysis of the reasons why deviations between NECPs have been introduced by TSOs (see [Recommendation 6 – Systematic scrutiny and validation by the NRAs of the input data provided by the TSOs](#)).

## 1.3 Scenarios modelling

This section provides a description of the tools used by ENTSO-E for ERAA and jointly ENTSO-E and ENTSOG for TYNDP for the modelling stage of the scenarios building process. More specifically, the section describes the models used, their functionality, the entities responsible for their development, update and utilisation, the way they are used in the scenario building process (what are the inputs and outputs and how are the different models linked between each other), and specific comments collected from stakeholders engaged in the scenario-building process.

### 1.3.1 Description of the modelling process

#### **TYNDP**

In TYNDP 2026, modelling activities have been conducted since September 2024 and are supposed to last for eighteen months. More specifically: six months of model preparation, four months for preliminary model calculations and sanity checks, and eight months for NT+ and variants calculations. The chain of models used is described in section [1.3.2. Tools used in TYNDP](#). During interviews, ENTSO-E and ENTSOG also highlighted the significant amount of work carried out to build and constantly improve the different tools used from the data collection to the models, and all associated scripts.

For TYNDP 2024 the dispatch model simulations (PLEXOS) were exclusively carried out by ENTSO-E for the National Trends+ scenario, while the modelling of deviation scenarios (DE and GA) was led by ENTSOG. For TYNDP 2026, both ENTSO-E and ENTSOG will contribute to carry out the simulations on the dispatch model (PLEXOS) for the central scenario<sup>59</sup>.

---

<sup>59</sup> Source: Meetings between Artelys and ENTOSOs.

## ERAA

The beginning of May 2023 marked the commencement of the modelling activities. In ERAA, the modelling process consists of two phases: the first one focuses on preparation, test runs, and model development, while the second is dedicated entirely to simulations. The timeline is approximately the same for every year. Between May and the end of June 2023, the adequacy model was developed, while in parallel, the EVA model (explained in chapter 1.3.3.1) was built between May and mid-June 2023<sup>60</sup>.

The first public consultation on methodology took place in mid-June 2023, covering the following topics:

- | Price cap determination
- | Explicit DSR modelling and expansion potentials
- | Maintenance optimisation in ERAA
- | Reserve modelling

From July to the end of August 2023, various simulations were conducted. Concurrently, at the beginning of August, ENTSO-E launched a second public consultation on methodology<sup>61</sup>, addressing the following topics:

- | EVA-related aspects
- | Energy islands
- | Network representations
- | Flow factor competition and curtailment sharing

In parallel with the simulations, the analysis of results was carried out, beginning in July 2023 and concluding in mid-September 2023.

ERAA team highlighted the long computational times (about three weeks in total, for Economic Viability Assessment + Economic Dispatch in ERAA 2024). This means that any re-run of the model (for instance for updating assumptions or fixing modelling bugs) takes at least 4 weeks (considering that at least one week is required to modify the model and check the results). Given the fact that ERAA is annual, and considering all other activities, which need to be carried out within the year, besides computation (data collection, model construction, results analysis etc.), the number of re-runs possible within each ERAA cycle is inherently limited. The ERAA team noted that the quality of the scenarios could be improved through more extensive checks on the data and re-runs of the models, but that these additional iterations are currently not possible given the existing time constraints.

---

<sup>60</sup> See [Link](#)

<sup>61</sup> See [Link](#)

## Recommendation 9 – Frequency of ERAA

The annual nature of the exercise could be questioned. Indeed, the need to update the ERAA every year should be seen in the light of the speed at which assumptions evolve. Switching to a biannual cycle (as for the TYNDP) would significantly reduce the pressure on the process and enable to spend more time on the inputs and scenario validation.

On top of allow for more time and occasions for stakeholders to provide feedback, switching to a bi-annual development cycle for ERAA would allow full alignment of the scenario-building process with the TYNDP timelines, in particular a further streamlining of the data collection for the two exercises, which would be beneficial for ensuring greater consistency between the two exercises.

This modification would require adaptation of the Electricity Regulation, since the annual rhythm of the ERAA is imposed by that regulation<sup>62</sup>.

## 1.3.2 Tools used in TYNDP

### 1.3.2.1 Energy transition model (ETM)

The Energy Transition Model (ETM) is a comprehensive, open-access online tool developed by Quintel Intelligence for building and exploring energy system scenarios. It covers all relevant sectors and energy carriers and aims to enhance transparency by providing quite detailed documentation<sup>63</sup> as well as a clear breakdown of energy demand by sector and carrier<sup>64</sup>.

In the context of TYNDP, the ETM is used exclusively for the demand component. Its purpose is to allow for greater visibility into demand structure, enabling to understand how different assumptions influence sectoral and carrier-level energy use.

The ETM was introduced for the first time in TYNDP 2024, replacing the previous Ambition Tool used by ENTSO-E and ENTSOG. In that edition, the ETM was mainly used to build the annual demand volumes<sup>65</sup> for the deviation scenarios (DE and GA), and was only manipulated by ENTSO-E and ENTSOG, while for the NT+ scenario, demand data was collected from the TSOs using Excel templates.

During the public consultation for TYNDP 2024, nineteen stakeholders responded to the question: "What are your views on the added value of this transition to the new tool (ETM) for the transparency of the scenario-building process?" The average score provided was 7.1 out of 10, indicating a generally

<sup>62</sup> Article 23(4) of the Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity (recast)

<sup>63</sup> Notably in the TYNDP 2024 Methodology Report (pages 19 to 21) and in the online ETM public documentation ([link](#))

<sup>64</sup> In TYNDP 2024, the links to the ETM scenarios for the different countries (for DE and GA scenarios) are available in the Excel file 'Demand Scenarios TYNDP 2024 After Public Consultation' which can be downloaded from the TYNDP 2024 Download page – [link](#).

<sup>65</sup> For some specific sectors (e.g. electric heat-pumps on district heating network), the ETM also provided load profiles (and not only annual demand volumes).

positive perception of the ETM’s contribution to improving transparency in the scenario development process<sup>66</sup>. It is possible to categorize the stakeholders who participated to the public consultation as follow: supply-side operators, associations involved in the electricity, gas and hydrogen markets, civil society representatives, energy consumer associations, EU DSO Entity, heating and cooling stakeholders, organisation in energy efficiency solutions, and supply-side operators. No further details are provided about who specifically the entities involved were.

### **Recommendation 10 – Transparency of the ETM tool**

The accessibility of the ETM parameters is key to unlock ETM’s added value to the scenario building process. Therefore, the publication of the ETM parameters for all countries is good practice which should be continued.

For further transparency, the links to the ETM workspace could be made more visible in the different deliverables of the scenario building process. In particular:

- | **Include references to ETM parameters in scenario documentation:**

The scenario building methodology report should explicitly mention that country-specific ETM input parameters are publicly accessible.

- | **Link directly to national ETM workspaces in deliverables:**

Each scenario report should include direct links to the ETM workspaces of the countries involved, ensuring stakeholders can quickly access the assumptions behind each national storyline.

- | **Ensure that TYNDP scenarios are fully accessible via the ETM interface:**

While the “TYNDP 2024 version” of the ETM is currently accessible, the underlying values of the input parameters are not always visible or downloadable. Full access should be granted to view and download these inputs.

- | **Document ETM assumptions and methodology:**

The ETM modelling approach — including constraints, and calculation logic — should be fully documented and open to public scrutiny. Evolutions of the ETM from a cycle to another (e.g. ability to handle several climate years – as described below) should also be publicly consulted before their implementation. This would significantly enhance transparency, traceability, and trust in the model outputs.

---

<sup>66</sup> TYNDP 2024 Consultation Summary Report

In TYNDP 2026, the ETM is used for the first time to collect from the TSOs the National Trends demand assumptions. The introduction of the ETM, in the demand data collection process, has significantly changed the process and the type of input parameters collected on demand:

- | Previously, the data collected from the TSOs was annual demand projections at different horizons.
- | With the ETM, the data collected from the TSOs is now the underlying drivers and parameters which explain the evolution of the demand over the years. This means that TSOs cannot simply enter the annual demand volumes (TWh/year) projected for the different sectors at the different horizons but have to find the right combination of sliders (actions on the demand) which enables to match the annual demand values of the forecasts (which should be based on the NECPs).

Several interviewed stakeholders reported that this new process was complex and time-consuming for the national TSOs, given the misalignment between the way the ETM model works and the objective of the demand data collection from the national TSOs. However, this retro-engineering step seems inevitable in order to obtain underlying demand drivers (and not only annual demand projections) in a consistent way across Member States, since these drivers are not always available from the NECPs, and that, when drivers are available, the link between demand drivers annual demand projections (i.e. the model used to project the demand in the NECPs) is not consistent across Member States. In particular, the critical aspect is to collect drivers and annual demand levels such that the relationship (the mathematical model) linking drivers to annual demand is consistent across Member States.

Moreover, some interviewed stakeholders reported that the miscalibration of the reference year 2019<sup>67</sup> in the ETM forced TSOs to provide unrealistic assumptions on the sectorial drivers (e.g. percentage of evolution of heat-pumps) in order to meet demand projections (in TWh/year) consistent with the NECPs.

Finally, the fact that the reference year is 2019 (six years from now) seems inappropriate. This means, for example, that the model must cover 11 years for the demand projection to 2030, which is more than twice as long as the period between now and 2030. While recognising that energy statistics take some time to be consolidated and published<sup>68</sup>, and that calibrating the ETM reference year (once public statistics are published) can also take some time, it would seem that basing the ETM on a more recent year is both desirable and possible.

---

<sup>67</sup> The miscalibration of the reference year of the ETM is also pointed out by the SRG in their feedback on the preliminary 2024 TYNDP Scenarios Results ([link](#))

<sup>68</sup> For instance, at the time of finalising this report (August 2025), the Complete energy balances from Eurostat (nrg\_bal\_c) were still not available for the year 2024.

### **Recommendation 11 – Use of the ETM tool for the data collection on National Trends demand assumptions**

The use of the ETM to collect demand drivers from the TSOs is a significant effort towards more transparency and uniformization of the demand projections among the different Member States. Moreover, the collection of underlying drivers and parameters which explain the evolution of the demand in the central scenario appears necessary to centrally build the TYNDP scenario variants around the central scenario (as further detailed in section [2.3.1.](#)). In this respect, the ETM could still be used to build the scenario variants.

According to stakeholders, the current implementation of this new tool suffers from several inconsistencies which affect its proper use and reduce the expected benefits. Therefore, additional efforts should be made to remove these barriers, to fully unlock ETM's promises. In particular:

- | The reference year used (2019 for the TYNDP 2024 and 2026 cycles) should be as recent as possible.
- | Efforts should be spent on the consistent calibration of the reference year (which should, to the extent possible, be based on official sources such as Eurostat). The reference year should also be as recent as possible.

The retro-engineering task of finding the right combination of demand drivers which enable to get the same demand forecasts as in the NECP is a highly complex task that the TSOs need to execute, but will remain a complex one even with the improvements suggested above. Therefore, national TSOs should be supported in this task. For instance:

- | Workshops should be organised to enable TSOs to report their difficulties and share between them good practices, in a collective learning process.
- | TSOs should get the support of NRAs and ministries, especially when the NECPs demand projections cannot be obtained with realistic values of the drivers.
- | Workshops should be organised with TSOs and ETM developers to determine which evolutions of the tool would facilitate the TSOs' task.

Stricter guidelines on how Member States should build their demand projections for their NECPs, and transparently report the underlying assumptions in their NECPs (e.g. by providing the list and value of drivers, as well as some documentation on the model used to build the demand projections) would also facilitate the preparation of central scenario, as well as the scenario variants (see [Recommendation 2](#)), and would allow these values to be formally recognised as the underlying assumptions of the NECPs.

Finally, efforts should be made to enable TSOs to transparently publish the procedure through which the sliders' values have been chosen (underlying assumptions taken by the TSOs, and potential difficulties faced by the TSOs to align the annual demand projections with the NECPs)<sup>69</sup>.

The demand volumes derived from the ETM are subsequently used as input to the Demand Forecasting Tool (DFT), which generates hourly electricity demand profiles for use in modelling and simulation activities.

TYNDP 2026 Innovation Roadmap<sup>70</sup> outlines several future improvements of the ETM. Here is a summary of the improvements:

- | **Improved reference values:** Updates residential heating technology shares using national statistics instead of relying on less granular EUROSTAT data and Quintel assumptions.
  - The value of the improvement is very high. The 2024 version lacked accuracy due to oversimplified or outdated assumptions. This upgrade enhances model credibility and cross-country consistency, which are critical for national-level scenario alignment.
- | **Climate year functionality:** In TYNDP 2024, the ETM used only one weather year to model energy demand and supply. Now, it can use multiple historical and climate-change-based weather years.
  - The value of the improvement is high. In 2024, reliance on a single climate year missed variability in energy demand/supply due to weather. This change improves the resilience of the tests and better reflects the importance of climate sensitivity in the long-term planning.
- | **Addition of countries:** Adds non-EU countries (e.g., Norway, Switzerland, Serbia) and splits UK data into GB and Northern Ireland.
  - The value of the improvement is high. Including them foster cross-border consistency and a better integration of EU energy system modelling.
- | **Integration of Supply Tool features:** Moves the functionality of the external Excel-based Supply Tool (details about the tool in chapter 1.3.2.5) into ETM, reducing external dependencies.
  - The value of the improvement is high. The split between demand and supply modelling in 2024 added complexity and risk of inconsistencies. Unifying the modelling logic improves coherence, usability, and auditability.
- | **Demand profile modelling:** Integration in the ETM of the possibility of generation of hourly demand profiles for electricity, methane, hydrogen, and heat.
  - The value of the improvement is medium. Previously, profiles were generated via disparate tools (DFT, or national TSO methods). Improving the workflow between annual generation estimates (previously in the ETM) and profiles generation (previously in the DFT) will streamline the process and reduce the risk of mistake and could enhance data traceability and scenario consistency, for demand-side flexibilities.

---

<sup>70</sup> TYNDP 2026 Innovation Roadmap

### 1.3.2.2 TYNDP gap filling methodology

As stipulated by the TEN-E Regulation<sup>71</sup>, TYNDP scenarios must be “fully aligned with the energy efficiency-first principle, the Union’s 2030 energy and climate targets, and its 2050 climate neutrality objective, and shall take into account the latest available Commission scenarios, as well as, where relevant, the national energy and climate plans (‘NECPs’).” Following the data collection phase, the ENTSO-E and ENTSOG are responsible for verifying that all inputs provided by the TSOs align with the European Commission’s final energy demand reduction targets for 2030. If discrepancies are found, the “NT+ Energy mix gap filling methodology”<sup>72</sup> is applied. Consequently, the scenario is then called National Trends+.

The gap filling methodology implemented in the TYNDP 2024 and proposed for the TYNDP 2026 process simply consists in comparing the total energy demand in 2030 obtained based on the data collected from the TSOs with the 2030 Energy Efficiency target, and to reduce the final demand of “solid fossil” and “crude oil and products” proportionally to the demand levels in the data collected from the TSOs<sup>73</sup>. In other words, this gap filling methodology enables to adjust the TYNDP central scenario in order to align them with the final energy demand reduction targets, but without modifying (and not even questioning) the electricity, hydrogen (and to a lesser extent methane) demand, which are the key energy carriers assessed in the TYNDP. Concretely, the gap filling methodology step for the TYNDP 2024 translated into a reduction by 37% of the coal final demand in 2030 (from 210 to 133 TWh on EU27) and a reduction by 27% of the oil final demand in 2030 (from 2816 to 2051 TWh on EU27)<sup>74</sup>. Given that the coal and oil infrastructure are not assessed as part of the TYNDP scenarios, it can be estimated that this stage had a negligible impact on the scenarios (despite its considerable impact on final demand for coal and oil). Following the public consultation on the gap closing methodology, the methodology has been extended to the 2040 horizon<sup>75</sup>. However, the gap filling methodology has not been applied to the 2050 horizon yet, given that the scenario National Trends did not cover 2050.

As described above, the methodology implemented for the TYNDP 2024 scenarios only focussed on the compliance with the Energy Efficiency target in 2030. No methodology has been designed in the TYNDP 2024 to ensure the compliance with the renewables or GHG reduction targets. However, the implementation of the gap filling methodology on the energy demand enabled as a side effect to make NT+ 2030 scenario compliant with the other EU targets: the overall share of renewables reach 45.4%

---

<sup>71</sup> See [Link](#).

<sup>72</sup> TYNDP 2024 Storyline Report, Annex 2.

<sup>73</sup> See [Link](#).

<sup>74</sup> TYNDP 2024 Scenarios Report – table 1 ([Link](#)).

<sup>75</sup> TYNDP 2024 Scenario report – Final version (January 2025) – page 53.

in NT+2030 scenario (versus 41.7% in the pre-gap-filling NT scenarios)<sup>76</sup>, and -63% of GHG emissions compared to 1990<sup>77</sup>. In 2040, NT+ scenario reaches -88% of GHG emissions compared to 1990.

The advantage of the gap-filling methodology as implemented in the TYNDP 2024 is its simplicity of application. In principle this simplicity is also merited given that the purpose of the TYNDP scenarios is not to close the gap between the NECPs and the European objectives.

At the same time, the methodology would also appear to be overly simplistic in situations where larger gaps appear between data provided by TSOs and the EU targets, thus the methodology can be rightfully criticized for artificially reducing demand for certain carriers (of “solid fossil” and “crude oil and products”) without really questioning the underlying realities on the different sectors, or how the surplus demand should be distributed between the different carriers. Under the current methodology, the larger the gap between the EU target and the demand reference value collected, the higher the uncertainty in the results derived from the alignment. This is because a linear scaling does not account for sectoral dynamics or technological feasibility. For example, when oil demand is artificially reduced, neither additional electrification needs nor the need to continue to meet transport demand is taken into account.

During the public consultation for TYNDP 2024, stakeholders provided several notable comments regarding the application of the gap-filling methodology. The main concerns raised were:

- | Some stakeholders questioned the simplistic approach of a gap-filling approach, arguing that proportionally reducing demand might be too simplistic. They noted that this method does not fully capture sector-specific decarbonisation pathways.
- | Several stakeholders suggested presenting two versions of the 2030 scenario: one based purely on NECP data and another adjusted to meet EU targets. This, they argued, would better illustrate the impact of the gap-filling adjustments.

NB: This question of having alternative non-target-compliant scenario variants will be further explored in introduction of the section [2.3](#).

- | Concerns were also raised regarding the uncertainties associated with the methodology, particularly how demand reductions were determined and the implications for other parts of the energy system. Stakeholders called for greater transparency in the assumptions and conversion factors used.

These comments highlight that stakeholders seek more detailed explanations (in terms of impact of the methodology on the energy system and scenarios results) and sensitivity analyses to address uncertainties in the gap-filling process.

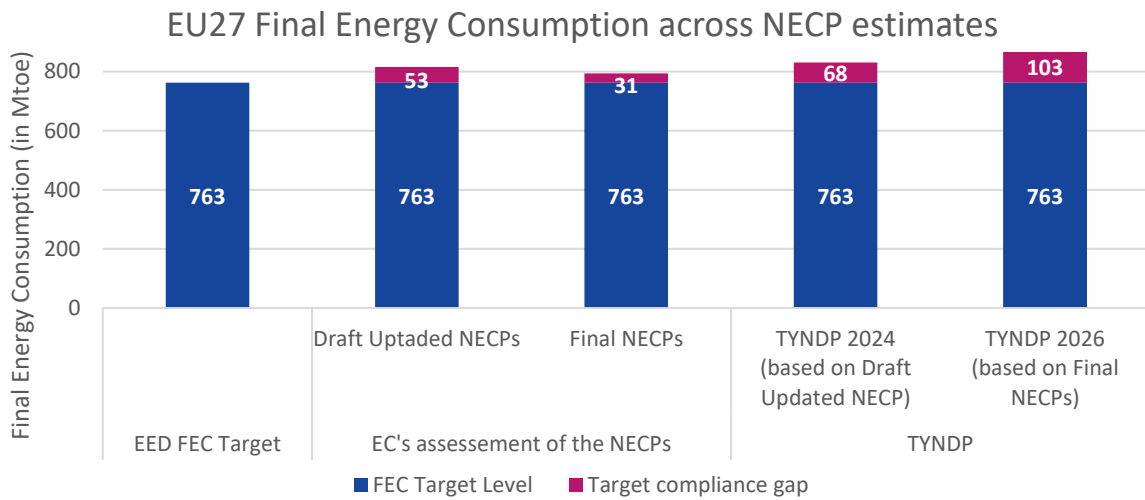
---

<sup>76</sup> TYNDP 2024 Scenario report – Final version (January 2025) – page 55.

<sup>77</sup> TYNDP 2024 Scenario report – Final version (January 2025) – page 56 (supplemented with the Excel annex “Scenario report data figures”).

**Comparison of the evolution of the gap between the TYNDP 2024 and TYNDP 2026 cycles**

The figure below illustrates the evolution of the final energy consumption (FEC) estimates for the EU27 towards 2030, compared to the binding target set by the Energy Efficiency Directive (EED), which is fixed at 763 Mtoe. The blue bars represent the EED FEC target, while the pink segments on top of the bars represent the target compliance gap which is the amount by which projected consumption exceeds the target.



**Figure 26 – Final energy consumption trends among different scenarios**

Interestingly, while the European Commission finds that the gap between the NECPs and the European targets is reduced in the final NECPs<sup>78</sup> compared to the draft updated NECPs<sup>79</sup> (from 53 to 31 Mtoe), the gap has increased in TYNDP 2026 data (draft values for public consultation) compared to the TYNDP 2024 data (from 68 Mtoe to 103 Mtoe, overshooting the 2030 objective by 13.4%)<sup>80</sup>. Two key findings can be drawn from this analysis:

- | The fact that the gap has increased between TYNDP 2024 and TYNDP 2026 raises questions about whether the gap filling methodology used in TYNDP 2026 is still appropriate for closing larger gaps. Indeed, the more the target compliance gap increases the less reliable the gap-filling methodology, in terms of precision, will become.

A threshold for the maximum acceptable discrepancy with the EU target could be defined in order to avoid the development of unrealistic scenarios. Beyond this threshold, the current methodology should no longer be seen as sufficiently reliable, and more sophisticated or iterative adjustment techniques should be considered to reduce the risk of error.

<sup>78</sup> European Commission’s EU-wide assessment of the final updated national energy and climate plans – Delivering the Union’s 2030 energy and climate objectives (SWD(2025) 140 final) – [link](#).

<sup>79</sup> European Commission’s EU wide assessment of the draft updated National Energy and Climate Plans – An important step towards the more ambitious 2030 energy and climate objectives under the European Green Deal and REPowerEU (COM(2023) 796 final) – [link](#).

<sup>80</sup> ENTSO-E and ENTSG’s webinar “Draft Scenarios Public Consultation Workshop” held on 4 July 2025 – [link](#) (see slide 47)

- | The fact that the gap has increased in the TYNDP while having decreased in the EC's assessment outlines the different approaches taken in the translation of the NECPs into scenarios. Further discussions between ACER and the EC have highlighted the fact that EC's assessment of the NECPs is based on **analysing the targets set out in the NECPs**, while the TSOs mostly rely on **specific scenario details in the NECPs**. Additionally, some differences could be explained by the fact that the EC relied on global equilibrium models to build harmonised demand projections between MSs, while such models are not used in the TYNDP process.

### Recommendation 12 – Gap filling methodology

While the gap filling methodology implemented in the TYNDP 2024 on first sight appears as a pragmatic approach to ensure the compliance of the NT+ scenario with EU energy targets, the methodology also presents significant shortcomings, which should be addressed in the TYNDP 2026 or future cycles.

In particular, the fact that the gap to fill has significantly increased between TYNDP 2024 and 2026 cycles, to reach 13.4%, raises the question of whether the methodology used in TYNDP 2024 is still fit-for-purpose. A precise gap filling methodology should be developed describing how the TYNDP scenarios should be adapted in case the compliance assessment reveals that the NECPs do not reach the Union targets. Indeed, the current gap-filling approach is well-adapted for moderate energy efficiency gaps, but is found not to be fit-for-purpose for larger energy efficiency ambition gaps or gaps relative to other targets. A simplified process could be put in place for TYNDP 2026, as the scenario building process is already ongoing, and should not be delayed by introducing a complex validation process for the gap-filling methodology.

A more sophisticated methodology will also be needed with a view towards future cycles, given that the methodology built for the TYNDP 2024 would not be relevant in a climate-neutrality context.

Moreover, the methodologies used to verify EU targets compliance by the European Commission and in the TYNDP should be aligned. Implementing this recommendation requires (a) to compare the NECP figures used by the European Commission in their analysis of NECPs with the datasets shared by TSOs with ENTSO-E and ENTSG, and (b) to agree on an approach to verifying compliance. A notable point of attention will be to differentiate between scenarios and targets announced in the NECPs, which may not always be aligned. This further investigation could also provide ideas on how to establish a robust gap-filling methodology for the TYNDP, including in cases where the gap to be resolved is significant (the first problem mentioned above).

Finally, it should be highlighted that filling this remaining gap is a difficult question which requires guidance and should not be the sole responsibility of ENTSO-E and ENTSG. For example, ACER-validated guidelines could be provided to ENTSO-E and ENTSG on how to carry out gap-filling. In addition, the European Commission could play a stronger role in supporting the ENTSGs in this process and ensuring consistency with EU policy objectives.

**NB:** for now, this gap filling methodology is only applied to TYNDP scenarios, and does not apply to ERAA scenarios. This is understandable given the fact that, by design, the current gap filling methodology does not impact electricity or hydrogen parameters, and that ERAA scenarios are limited to electricity and hydrogen.

It should nevertheless be emphasised that discussions on changes to the gap filling methodology must be conducted not only in the context of the TYNDP scenarios, but more broadly in the context of all NECP-based scenarios (including ERAA). In particular, if the gap filling methodology were to be modified in such a way that it could impact the assumptions of the electricity or hydrogen systems (e.g. impact the electricity or hydrogen demand), then it would be crucial to apply this methodology to the ERAA as well, so as not to introduce discrepancies between the two scenarios<sup>81</sup>. For complementary information, see section [0](#).

[Compliance with EU climate goals.](#)

### 1.3.2.3 Demand forecasting toolbox (DFT)

*The demand forecasting toolbox is used for both ERAA and TYNDP processes. Therefore, this section applies to both exercises.*

For creating electricity hourly load profiles for most European countries, ENTSO-E relies on a tool that enables to generate hourly electricity demand timeseries for different climatic years. This tool comes in the form of software developed by an external provider<sup>82</sup>. Known as the Demand Forecasting Toolbox (DFT), the tool is designed to streamline forecasting activities, ensuring more consistency and comparability across the forecasts from ENTSO-E members.

Concretely, the DFT works with the following steps:

- | **A statistical model is trained** on recent historical data for each country. The training dataset contains hourly electricity demand and hourly climate conditions (temperature, irradiance, wind speed etc.) time series of a few recent years, as well as calendar effects (weekdays vs. weekends, national holidays etc.). The objective of this model is to predict the hourly electricity load based on the climate and calendar conditions.
- | Then, **this statistical model is projected on a large number of climate years**. Until ERAA 2023 and TYNDP 2024 cycles, the climate data were historical data (from 1982 to 2016). From ERAA 2024 and TYNDP 2026 cycles, the climate data used are climate projections (between 2025 and 2060). The number of climate years actually used in the subsequent modelling steps

---

<sup>81</sup> Even if, unlike TYNDP, ERAA is not explicitly required to be compliant with long-term EU targets and focuses only on electricity, ERAA methodology requires that “scenario assumptions shall align with the latest NECP-based TYNDP scenario” (ACER Decision on the ERAA methodology: Annex I – [Link](#) – Art. 3.3(a)). Therefore, if the gap filling methodology impacts TYNDP assumptions related to electricity or hydrogen, then ERAA’s corresponding assumptions should be adapted accordingly.

<sup>82</sup> TYNDP 2024 Methodology Report, page 65.

depends on the exercises and scenarios: while ERAA models more than 30 climate years in the Economic Dispatch, in order to accurately represent the occurrence of extreme climate conditions, TYNDP 2024 National Trends+ scenario was modelled on one single climate year (2009), the TYNDP 2024 deviation scenarios (DE and GA) on three climate years (1995, 2008 and 2009).

- | The last step of the DFT is to adjust load-curve shape to reflect changes in the electricity market, such as the growing use of heat pumps, electric vehicles, batteries, and shifts in the base load.

What sets the DFT apart from traditional forecasting methods is its ability to reconstruct full daily load profiles. This is achieved by isolating key load components through a mathematical analysis of historical data. The process involves predicting the entire daily load, identifying changes throughout the year, and factoring in specific conditions like bank holidays at particular market nodes, seasonal shifts (such as daylight-saving time or summer holidays), and other patterns.

At the core of the tool's methodology is Singular Value Decomposition (SVD), which breaks down the load data into a few independent components. These components serve as ideal building blocks for reconstructing a typical daily load profile. SVD has the advantage of ranking these components by importance, so the first few capture most of the relevant information. These components are typically linked to different physical factors of the load, which means they have distinct dependencies on climate conditions or types of days.

The DFT includes three machine learning algorithms for modelling hourly electric load time series, offering accurate forecasts of future load curves. These methods not only provide precise predictions but also offer insights into the main factors influencing load trends. The algorithms available in the DFT are<sup>83</sup>:

- Generalised Additive Models (GAM)
- Random Forest
- Linear Regression

In ERAA and TYNDP, the DFT is specifically used and managed by ENTSO-E. In the case of TYNDP (NT+), the DFT receives the following inputs:

- Historical load and calendar data (total & sectorial)
- Climatic data from PECD
- EVs, Heating & Cooling devices, batteries and other parameters from PEMMDB
- Annual electricity demand from ETM

As an output, it produces timeseries of hourly electricity demand profiles, which becomes an input to the dispatch model in TYNDP, and to the EVA and ED in ERAA.

---

<sup>83</sup> TYNDP 2024 Methodology Report, page 65, 66, 67.

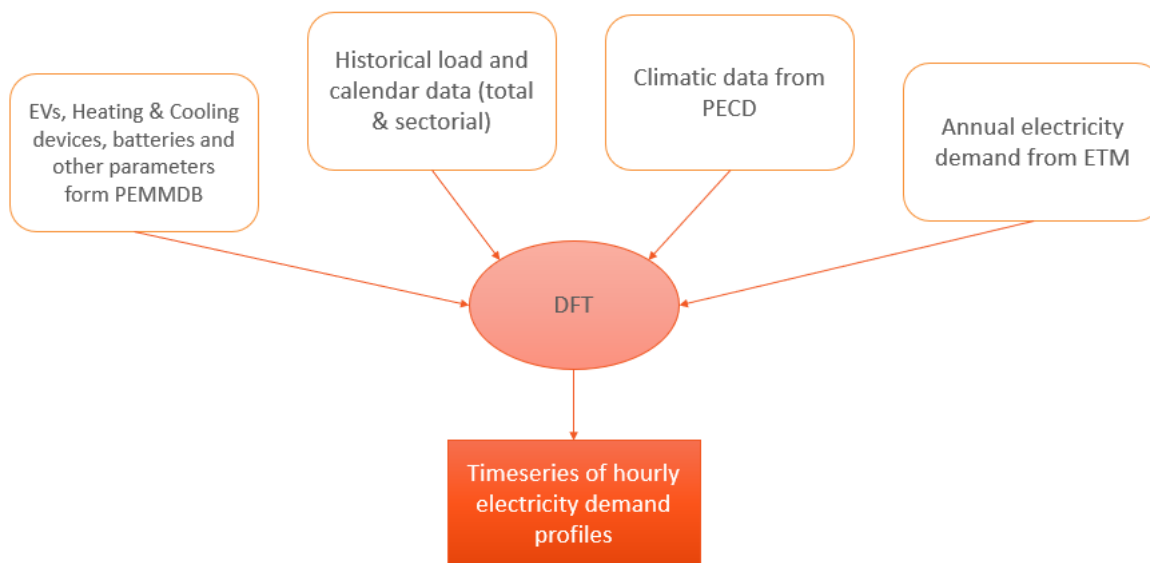


Figure 27 – DFT functioning flowchart

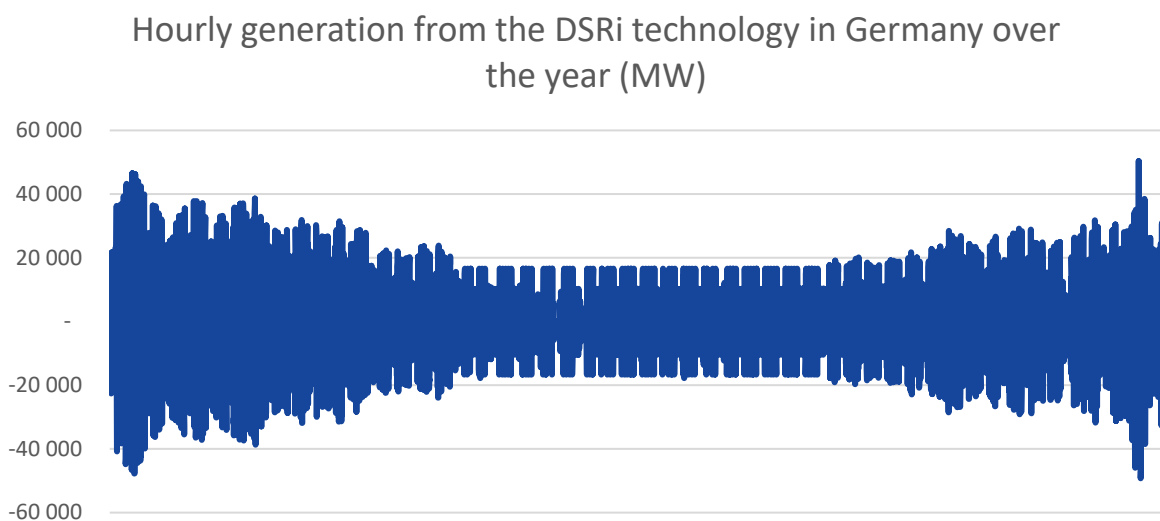
Flexible consumption (e.g. flexible EVs, heat-pumps etc.) need to be specifically represented in the dispatch optimisation models (both for ERAA and TYNDP). Two main approaches are possible:

- | Flexible demand can be represented with **dedicated energy consumption models in the dispatch model**, which consume energy, but in a flexible way (under specific technical constraints). In this case, the consumption from these flexible assets must be excluded from the hourly electricity demand profiles, in order to avoid double counting. This approach is for instance implemented in TYNDP 2024 deviation scenarios for electric vehicles.
- | Flexible demand can also be represented with a **virtual battery, which only represents the possibility to shift load**, but does not consume energy (or in other words consumes and produces exactly the same amount of energy over the year). In this case, the native demand has to be included in the hourly electricity consumption profiles generated with the DFT. This approach has for instance been implemented in the TYNDP 2024 central scenario.

The low level of transparency on demand flexibility parameters should also be highlighted (for instance ‘demand-side response implicit’ is not mentioned in the TYNDP 2024 methodology report, and no input data could be found on it among the different input files published by ENTSO-E and ENTSG), despite its significant impact on the scenario. For instance, in the TYNDP 2024 NT+ 2009 scenario, the ‘implicit demand side response’ asset maximum power reaches 50 GW in Germany, generates 32 TWh over the year<sup>84</sup>. One NRA also reported that assumptions regarding the demand development are often not aligned with the “assumed DSR potential”<sup>85</sup>. This statement is however difficult to verify given the low level of transparency on the demand flexibility assumptions.

<sup>84</sup> ENTSO-E & ENTSG TYNDP 2024 Scenarios – Outputs - NT+ 2040 Modelling Results – Climate Year 2009 (v40, downloaded on the 13<sup>th</sup> June 2025), worksheet ‘Hourly Market Data’ - [Link](#)

<sup>85</sup> Source: Artelys’ survey to NRAs.



**Figure 28 – Hourly generation from the demand-side response implicit (DSRi) DSRi technology in Germany over the year, in the scenario TYNDP 2024 NT+ 2040 – climate year 2009<sup>84</sup>**

### **Recommendation 13 – Transparency of the demand-side flexibility assumptions**

The level of transparency of demand-side flexibility should be improved, in terms of:

- | Model description (e.g., provision of details on the way implicit demand side response is represented in the dispatch model)
- | Dispatch model input data (publish the value of the different parameters, notably activation costs, availability timeseries and cycling constraints)
- | Description of the flexibility parameters building process

#### **1.3.2.4 Joint Electricity and Hydrogen dispatch optimisation models**

Generally speaking, dispatch optimisation models aim at defining which technology is generating when, in order to meet the demand at the lowest cost, considering storages, interconnections, potentially demand flexibility etc.

As the hydrogen economy becomes increasingly tied to the development of electrolysis, it is essential to adopt an integrated approach to modelling both electricity and hydrogen. In the TYNDP 2024 model, electricity and hydrogen are optimised in a similar way: the model optimises the hourly dispatch of electricity and hydrogen generation assets, storages, demand-side flexibilities and cross-border interconnections (both transmissions and pipelines) in order to meet both electricity and hydrogen demands at the lowest system cost.

For TYNDP 2024, the main dispatch tool used was PLEXOS. Other dispatch tools (Antares, Promed, and APG<sup>86</sup>) were used for NT+ scenario, with the main objective of validating the model to guarantee its

<sup>86</sup> TYNDP 2024 Methodology Report, page 24. Deviation scenarios (DE and GA) were only modelled on Plexos.

robustness. The idea behind using these different tools is to compare results for accuracy<sup>87</sup>. However, experience has shown that PLEXOS is the main tool relied upon by the ENTSO-E and ENTSG<sup>88</sup>.

Up until the TYNDP 2024 version, the PLEXOS model for the NT+ scenario was built and managed by ENTSO-E only, while ENTSG oversaw the modelling part for the deviation scenarios (DE and GA). Whereas, starting with TYNDP 2026, ENTSO-E and ENTSG will collaborate on the modelling efforts for the NT+ scenario<sup>89</sup>.

The high-level parameters used as inputs for the dispatch model include the following. A complete list of specific parameters can be found in the inventory of parameters provided in the accompanying Excel file.

- Electricity sector modelling:
  - Hourly electricity final demand. The annual electricity demand is an output of the ETM and an input to the DFT, which then produces the hourly electricity demand profiles.
  - Generation installed capacity and other technical parameters of the different technologies (incl. hourly availability timeseries for the renewables, maintenance planning for thermal capacities and nuclear), coming from the PEMMD App and excel files provided by ENTSG.
  - Storage capacity and other technical parameters, coming from the PEMMD App and excel files provided by ENTSG.
  - Electricity reference grid (net transfer capacity values representing interconnections between market zones, provided by TSOs)
- Hydrogen sector modelling:
  - Hourly hydrogen final demand. ENTSG provides the methane profiles, which then are considered as hydrogen profiles. It is an input to the dispatch model.
  - SMR capacity. The data is provided through excel file filled by TSOs and given to ENTSO-G. It is an input to the dispatch model.
  - Storage capacity. The data is provided through the PEMMDB App and it is an input to the dispatch model.
  - H2 import terminal capacities
  - H2 imports potential. Different external studies have been used, such as: TYNDP 2022 PCI projects, European Hydrogen Backbone, IEA Global Hydrogen Review, IRENA, Marocco H2 Strategy. It is an input to the dispatch model.
  - Hydrogen reference grid (cross-border transmission capacities across Europe)
- Sector coupling modelling
  - Electrolysis installed capacity and other technical parameters. The data is provided through the PEMMDB App.

---

<sup>87</sup> TYNDP 2024 Methodology Report, page 25.

<sup>88</sup> Source: Meeting with the ENTSGs.

<sup>89</sup> Source: Meeting between Artelys and the ENTSGs

- Hydrogen-to-power installed capacity. Input provided through the PEMMDB App.
- Commodity prices

The dispatch model produces the following outputs. A more detailed list can be found in section [1.4. Scenarios outputs and finalisation](#).

- Electricity annual and hourly generation from the different technologies (RES, hydro, thermal) and imports
- Utilisation of electricity flexibilities (batteries, DSR, pump storage)
- Electricity flows between zones.
- Methane demand for power and hydrogen generation
- Hydrogen generation from the different technologies (SMR, electrolysis) and imports
- Hydrogen storages operation
- Hydrogen cross-zonal flows
- CO2 emissions from electricity and hydrogen generation

### 1.3.2.5 Supply Tool

The Supply Tool is designed to gather in a single file all the energy demand from all energy carriers and determine how this demand is met from the different sources (mainly domestic renewable production (e.g. biomethane) and imports (methane, hydrogen, liquids, solids, biomass). The supply tool enables to provide an overview of energy consumption, to calculate the contribution of different energy carriers (e.g., electricity, gas, hydrogen, biomass) to meeting the future energy needs of Europe<sup>90</sup> and calculate total greenhouse gas emissions.

On the demand side, the Supply Tool gathers<sup>91</sup>:

- | **Final energy demand** of energy carriers **explicitly represented in the dispatch optimisation model\*** (electricity and hydrogen). This data is an output from the ETM and an input of the dispatch optimisation model.
- | **Final energy demand** of energy carriers **not optimised in the dispatch optimisation model\*** (methane, liquid, solid, biomass). This data is an output from the ETM.
- | **Intermediate energy demand** for electricity and hydrogen generation (e.g. methane, hydrogen, solids, liquids and biomass consumption for power generation, methane and electricity consumption for hydrogen generation). These values are results of the dispatch optimisation model.
- | **Intermediate energy demand** for other energy carriers (for instance methane, liquid, and solid demand for heat generation\*\*, biomass demand for bio diesel, bio ethanol etc.

<sup>90</sup> TYNDP 2024 Methodology Report, page 21.

\*Including demand for conversion

\*\* Except for district heating

<sup>91</sup>

On the supply side, the model works in a very simple way: the main inputs are the domestic generation potential of each energy carrier (fossil methane, biomethane, oil and liquids, coal and solids etc.). All the domestic generation comes from the data collection and from PLEXOS (e.g., hydrogen domestic production (SRM, SRM+CCS, P2G) comes from the PLEXOS). The imports of each energy carrier are computed as the difference between the total demand (considering both the final demand and the intermediate energy consumption) and the domestic production.

The tool works at the country level (one worksheet for each country + worksheets with the total values) and only works on an annual basis (no hourly or daily results and no information on the peak demand are available). The electricity supply is never reported in the supply tool (which make sense given the yearly granularity of the supply tool).

### 1.3.3 Tools used in the ERAA

The modelling chain for the ERAA is simpler than for the TYNDP, as it consists of three main steps:

- | First, the Demand Forecasting Tool described above enables to generate hourly electricity demand timeseries for a large number of climate years. In the ERAA, the yearly electricity demand is directly gathered and uploaded in the DFT by the TSOs. The demand time series generated by the DFT are used in the two subsequent steps described below.
- | Second, an Economic Viability Assessment (EVA) model is run to determine the peak capacities which are foreseen by the TSOs but economically not viable under current market conditions, and which should therefore not be considered as operational in the Unit Commitment Economic Dispatch (UCED – hereinafter referred to as “ED” for simplicity).
- | Finally, the Economic Dispatch (ED) is run on a large number of climate years and outage patterns to determine resource adequacy and loss of load probabilities. The ED takes as input the demand profiles from the DFT and post-EVA installed capacity assumptions.

#### 1.3.3.1 Economic Viability Assessment (EVA)

The objective of the EVA is to modify the capacity mix assumptions used as an input to the scenarios, in order to remove the generation units participating in the energy only market (EOM)<sup>92</sup> that are not economically viable. The underlying reasoning is to consider that non-viable power plants are likely to be decommissioned by their operators and therefore should not be considered as resources available to meet demand in the future, even if included in the NECPs or TSOs projections. Symmetrically, the EVA also enables to commission additional generation units or extend their lifetime if they are economically viable when participating in the EOM.

This viability is assessed using a long-term planning model that jointly optimises the hourly dispatch with capacity expansion/retirement of some technologies, in order to minimise total system costs. As

---

<sup>92</sup> ERAA 2023 Annex 2: Methodology, page 38.

a result, the assessment provides insights into the resources that are most likely to be retired, invested in, mothballed or demothballed, or have their operational life extended, for each study zone and across the modelled time periods. The decision variables for the available resources are determined by the specific technologies and fuel types of the generation assets, as well as country-specific data when relevant (for example, thermal units eligible for mothballing or life extension)<sup>93</sup>. Commissioning/decommissioning is optimised MW by MW (and not unit by unit). It is important to bear in mind that there may be additional exogenous assumptions for which units cannot be retired such as local considerations, national policies, support schemes and country specification. Therefore, any other unit labelled by TSOs as a 'policy unit' in the PEMMDB will not be a decommissioning candidate. Similarly, must-run units or units with a capacity market contract in place are not considered as decommissioning candidates.

The EVA may start with slightly different resource capacities compared to the National Trend scenario, particularly regarding the TSOs projections. This discrepancy arises from a few key factors. First, simplifying assumptions are made about the decommissioning dates of units included in the EVA: in the economic dispatch, unit (de)commissioning dates are based on the dates provided by the TSOs and can happen at any time of the year. For instance, if a unit gets decommissioned in the middle of a year, then its availability will be set at 0 for the rest of the year. On the opposite, in the EVA, units can only be (de)commissioned on the 1<sup>st</sup> of January. In other words, the (de)commissioning dates provided by the TSOs are rounded to entire years. The cut-off date for these decisions is set as July 1st of each year. If a unit's decommissioning date falls before this date, it is not considered in the calculations for that year. On the other hand, if the decommissioning happens after this date, the unit is treated as commissioned for the entire year of decommissioning and decommissioned in the following year. Additionally, secondary fuels are neglected in the EVA. For units using both primary and secondary fuels, the primary fuel is assumed to apply to the entire installed capacity of the unit<sup>94</sup>.

The EVA utilises 3 climatic years, based on gathered data for four non-consecutive Target Years (TYs): 2025, 2028, 2030, and 2033. However, the EVA operates as an integrated model spanning the entire period from 2025 to 2033. To address this discrepancy, it is assumed that data for non-TYs are replicated from the most recent available TY. For instance, the years 2026 and 2027 are assumed to share the same load, generation capacity, network constraints, and other relevant parameters as TY 2025. The choice of the number of climatic years has a direct impact on the computation time, which is one of the main topics of debate among the stakeholders for future editions of the ERAA.

The approximate computation time for EVA simulations is around one week for the three climatic years<sup>94</sup>.

---

<sup>93</sup> ERAA 2023 Annex 2: Methodology, page 36.

<sup>94</sup> ERAA 2023 Annex 2: Methodology, pages from 36 to 44.

The detailed list of parameters used in EVA is in the Excel inventory of input parameters provided as an annex to the present report. The outcomes provided by the EVA simulations include the following key parameters. Moreover, a detailed list of outputs is provided in section [1.4.2](#).

- | Thermal capacity commissioned
- | Thermal capacity decommissioned
- | Battery capacity commissioned
- | DSR capacity commissioned

The modelling tool used for the Economic Viability Assessment (EVA) is PLEXOS.

### 1.3.3.2 Unit Commitment Economic Dispatch (UCED)

The Unit Commitment and Economic Dispatch (UCED) process is the main stage in assessing the adequacy of power system resources. This approach, which follows the EVA, uses two primary KPIs to measure system performance: Loss of Load Expected (LOLE) and Expected Energy Not Served (EENS).

The UCED process is carried out in two steps. The first step, known as the unit commitment problem, involves determining the optimal on/off status of each generating unit over a specified time period. The second step, the economic dispatch, optimises the generation levels for each committed unit to minimise the total system costs. Both steps are solved simultaneously in a co-optimisation process, ensuring that the overall costs are minimised while fulfilling the electricity demand.<sup>95</sup> The granularity of the simulations is hourly and a flow-based market coupling approach for cross-bidding-zone exchanges is used for the zones where flow-based is effectively used for day-ahead markets.

For the UCED, the overall computational time mainly depends on the number of servers/PLEXOS licences which can be used in parallel. Indeed, because all the test cases (combination of climate years and outage profiles) are independent, they can be run in parallel on various servers. Currently, thanks to the utilisation of both PLEXOS licences hold by ENTSO-E secretariat as well as licences acquired by some European TSOs, the computation time for the Economic Dispatch is around two weeks. This, in addition to the week for EVA, makes the entire simulation process lasting 3 weeks. In case of necessity to rerun the UCED simulation, the EVA must also be rerun. In this case, it needs one week to change the inputs, leading to a total duration of 4 weeks<sup>96</sup>.

Once the optimisation process is completed, the system generates the market dispatch results, meaning the specific generation profiles at each time step. Then, a post-processing stage implements the curtailment sharing<sup>97</sup>. Curtailment sharing aims to equalise as much as possible the curtailment ratios between those bidding areas that are simultaneously in a curtailment situation and those that are configured to share curtailment. In other words, curtailment sharing aims to 'fairly' distribute the

---

<sup>95</sup> ERAA 2023 Annex 2: Methodology, page 48.

<sup>96</sup> Source: Meeting between Artelys and ENTSO-E.

<sup>97</sup> ERAA 2023 Annex 2: Methodology, page 54.

curtailments across the involved markets by equalising this curtailment ratio. The curtailment ratio is defined as curtailed price-taking orders / total volume of price-taking orders.

Finally, the adequacy metrics (LOLE and EENS) are calculated, which provides insight into the system's ability to meet demand under various conditions<sup>98</sup>. A graphical explanation of the process is available in ERAA 2024 Annex 2: Methodology (figure 20).

The UCED uses 36 climatic years<sup>99</sup>, against the 3 used by the EVA. As mentioned before, this is a central topic of discussion for stakeholders. More specifically, both ACER and the German Ministry have identified discrepancies regarding the weather years between EVA and ED modules, on top of that, ACER proposed for ERAA 2024 the alignment of the two timeframes to ensure more consistency and accurate results. However, ERAA 2024 did not change this approach<sup>100</sup>.

Until ERAA 2023 PLEXOS was the only tool used for simulations by ENTSO-E, while from ERAA 2024 it has been decided to give the possibility to the TSOs to run simulations on their personal tools with the goal of assessing the consistency and reliability (cross-checking with parallel simulations using other tools) the final results. However, it is important to underline that PLEXOS is the main tool for ERAA simulations<sup>101</sup>, in the sense that all the results published are coming from PLEXOS.

#### **Recommendation 14 – Utilisation of several modelling tools in parallel**

The use of several modelling tools in parallel is a good practice to ensure cross-validation and improve the robustness of models<sup>102</sup>. The only risk of this approach is to introduce inconsistencies by publishing results from different models (which are not always perfectly aligned). To avoid this, a single model should be used as a reference (from which all the published results are taken) and using the other models only for the purpose of cross-validating the reference model (as it is currently done by ENTSO-E).

## 1.4 Scenarios outputs and finalisation

This chapter aims to provide a comprehensive inventory of all outputs produced within the frameworks of the TYNDP and the ERAA. First, it is important to make clear that:

- | For the TYNDP: the output results provided in this chapter are the ones for the scenario development process, which are subsequently used as input to the infrastructure gaps identification exercise and to the projects' CBAs.

<sup>98</sup> ERAA 2023 Annex 2: Methodology, pages from 46 to 54.

<sup>99</sup> The number of climate years was 35 until ERAA 2023 (from 1982 to 2016) and is 36 from ERAA 2024 (from 2025 to 2060).

<sup>100</sup> ACER DECISION No 06/2024

<sup>101</sup> Source: Meeting between Artelys and ENTSO-E.

<sup>102</sup> This approach was for instance implemented to support the Impact Assessment of Europe's 2040 climate target (SWD/2024/63 final [link](#) – the four models were PRIMES (used as the reference model), POTEnCIA, METIS, EU-TIMES and POLES), and used to be implemented in ENTSO-E's Mid Term Adequacy Forecasts.

- | For the ERAA: The output results provided in this chapter are the final results from the entire ERAA exercise.

In addition, it includes a detailed assessment of the transparency level of each output, focusing on how clearly and to what degree of granularity the outputs are presented in publicly available documents. The analysis is specifically based on the TYNDP 2024 and the ERAA 2023.

Moreover, the chapter outlines the final stages of scenario development, including the consolidation and publication process, offering insight into how the scenarios are finalised and made available to stakeholders and the public.

### 1.4.1 TYNDP’s inventory outputs

While the ERAA provides almost only graphical information through the “Detailed Results” report, for the TYNDP scenarios it is possible to access publicly available excel files with all the final output values.

A detailed list of all the outputs from PLEXOS – for the National Trends+ scenario, which considers the years 2030 and 2040 – is provided below<sup>103</sup>:

Output	Description
<b>Yearly outputs</b>	
<b>Annual generation [GWh]</b>	Annual generation for every technology fleet and bidding zone.
<b>Loss of load expectation [hour]</b>	Probabilistic metric estimating the expected number of hours per year and bidding zone in which supply is insufficient to meet demand.
<b>Net annual country balance [GWh]</b>	Net annual electricity import or export position of a bidding zone over a full year.
<b>Exchanges with non-modelled nodes [GWh]</b>	Annual electricity flows (imports or exports) between a modelled bidding zone and external nodes that are not explicitly represented in the simulation.
<b>Dump energy [GWh]</b>	Annual electricity that is generated but cannot be used or stored, and must be intentionally "dumped" (discarded), per bidding zone.
<b>Unserved energy [GWh]</b>	Annual amount of electricity demand that could not be met due to insufficient generation, transmission, or flexibility resources.
<b>CO2 emissions [tons]</b>	Annual CO2 emissions per bidding zone.
<b>Full load hours [hours]</b>	Equivalent number of hours per year that a power plant (or energy resource) would need to operate at 100% capacity to generate its actual annual output.
<b>Total income [M€]</b>	Total annual income per technology fleet and bidding zone.
<b>Total system costs [M€]</b>	Total annual system cost per bidding zone.

<sup>103</sup> TYNDP2 2024 Scenarios Outputs (Excel files)

<b>Spilled energy on hydro plants [GWh]</b>	Annual volume of water (and thus potential electricity) that is intentionally or unintentionally released without being used for power generation. Data provided for every bidding zone.
<b>Hourly cross border exchanges [MW]</b>	List of hourly cross-border exchange among countries, per each year (2030 and 2040).
<b>Hourly market data (by technology and bidding zone)</b>	
<b>Technologies hourly dispatch [MW]</b>	Per technology fleet and bidding zone.
<b>Hourly energy not served [MW]</b>	Same concepts explain above but with hourly granularity.
<b>Hourly marginal cost [€]</b>	Same concept explained above but with hourly granularity.
<b>Hourly dumped energy [MW]</b>	Same concept explained above but with hourly granularity.
<b>Hourly power balance [MW]</b>	Same concept explained above but with hourly granularity.
<b>Yearly and hourly H2 outputs (by bidding zone)</b>	All the parameters mentioned previously for electricity are produced also for Hydrogen. The technologies are electrolyzers, H2 storage discharge (gen.), H2 storage charge (load), and steam methane reformers.

Furthermore, the level of transparency is considered being very high because all outputs results are provided in excel files with all levels of granularity and details mentioned in the table.

In addition, the Excel-based supply tool is also publicly available.

## 1.4.2 ERAA's inventory outputs

Contrary to the TYNDP, the ERAA's output data is mostly provided through graphical representation directly in the reports, instead of external Excel files with numerical results (except for the hourly energy not served (ENS)).

<b>Output</b>	<b>Description</b>	<b>Transparency</b>
<b>Loss of Load (LOL)</b>	Measures the expected number of hours with Loss of Load (LOL) due to insufficient capacity.	Table with results for each target year (horizon), at the bidding zone level. The detail of each test-case (in the sense of each climate year x random outage profile) is not provided. Instead, the average (called Loss of Load Expectation – LOLE) and percentile (P50 and P95) of the multiple test-cases are provided.
<b>Hourly Energy Not Served (ENS)</b>	Measures the energy that would have been required but was not delivered during the adequacy risk periods.	High level of transparency as the data is provided in a public excel file.
<b>Capacity changes induced by the EVA. (decommissioned, mothballed and</b>	Differences between the pre-EVA and post-EVA installed capacities.	Table with the results for each TY, at the country and bidding zone level.

<b>additional capacities as well as life extension of existing units)</b>	Mothballed capacities refer to generation units that are temporarily removed from the market due to economic conditions but could potentially be reactivated if market conditions improve.	
<b>Revenues and profitability analysis for thermal expansion units</b>	Scarcity revenues <sup>104</sup> and average capacity factor (%) for new gas capacity in the EVA. The graphical representation shows the percentage of revenues that the new gas capacity receives during near-scarcity hours and the average capacity factor over the researched horizon and depending on the year of commissioning.	Table with results for different CY (1985, 1988, 2003).
<b>Yearly net profits per installed MW of new gas capacity</b>	In the EVA, annualised net profits are calculated by subtracting the components of CAPEX and fixed operating costs from the net revenues generated by the new capacity.	Table, for the different TY (2028, 2030 and 2033), and CY (1985, 1988 and 2003).

### Recommendation 15 – Transparency of ERAA’s modelling results

It would be recommended for ERAA to use the same approach as for the TYNDP, meaning to provide the final output results also in an Excel format besides graphical representation, for the sake of completeness.

Moreover, in addition to the specific adequacy results, ENTSO-E should also publish more general modelling results, such as generation and consumption by unit or technology and by zone. Indeed, although determining the annual generation and consumption by unit or technology is not the objective of the ERAA, the publication of this data would facilitate the recalibration of ERAA-based models by third parties (e.g. for the purpose of building National Resource Adequacy Assessment, national Flexibility Needs Assessment, or more broadly to enable any party to explore scenarios).

While acknowledging that it is impossible to publish detailed hourly results for all climate years and all outage draws, at the unit granularity, both for reasons of dataset size and of data confidentiality, the following solutions should still be considered:

- | Publish hourly generation and consumption results and by zone, but with units aggregated by technology and sub-technology (similarly to TYNDP), for a selection of climate years and outage draws.
- | Publish annual generation and consumption results by unit, or failing that, aggregated by technology and sub-technology for each zone.

<sup>104</sup> Scarcity revenues: revenues coming from periods in which the market price is higher or equal than 50% of the cap price.

### 1.4.3 Finalisation & publication

#### **TYNDP**

In the TYNDP 2026, the drafting of the scenarios report is supposed to start in July 2025 and last for 9 months. The public consultation on the draft NT+ results<sup>105</sup> and the scenario variants has started on the 1<sup>st</sup> of July and will terminate on the 29<sup>th</sup> of July. After the public consultation, the draft scenario will be published and submitted to ACER, the European Commission and the Member States for their opinion. According to the TEN-E Regulation, ACER is given 3-months following this submission to issue an Opinion. Subsequently, the European Commission is given three further months to approve the draft joint scenarios or request the ENTSO-E and ENTSG to amend it.

According to this process, the ENTSO-E and ENTSG are expected to publish the final scenarios package in October 2026 following the approval of the draft report by the European Commission.

#### **ERAA**

The drafting of the ERAA 2023 report began in May 2023 and was completed by the end of November 2023 by ENTSO-E<sup>106</sup>. At this stage, ENTSO-E launched a public consultation on the results, which commenced on 18 December 2023 and concluded on 31 January 2024<sup>107</sup>.

In parallel, ENTSO-E organised a stakeholder webinar, on the 10<sup>th</sup> of January 2024<sup>108</sup>, to present the results and key messages of the ERAA 2023 edition. The webinar covered the following topics:

- | Key takeaways from ERAA 2023
- | Input data and methodological improvements
- | Major outcomes of ERAA 2023

Once ENTSO-E analysed the feedback from public consultation and made the corresponding amendments, the draft report was published by the ENTSO-E and ENTSG and subjected to validation and amendments from ACER. The latter approved ERAA 2023 on May 13, 2024<sup>109</sup>.

---

<sup>105</sup> [Link](#)

<sup>106</sup> See [Link](#), slide 9.

<sup>107</sup> See [Link](#)

<sup>108</sup> See [Link](#)

<sup>109</sup> See [Link](#)

## 2 Task 2 – Construction of scenario variants for TYNDP and construction of an additional scenario for ERAA

The objective of this chapter is to propose methodologies for the construction of the following scenarios:

- | **An additional ERAA scenario:** A scenario based on observed trajectories and that can potentially deviate from NECP targets.
- | **Two TYNDP scenario variants:** The “Low-economy” and “High-economy” variants that derive in a realistic way from the central scenario and create a cone of values around the latter.

The proposed methodologies should be **transparent, robust** and **replicable**. This section also provides **concrete examples**, as well as suggestions for **suitable data sources**. When necessary, data availability challenges are pointed out and **recommendations** to tackle them are proposed. Pragmatic simplified approaches can also be suggested when necessary.

In order to inform proposals for additional scenarios and variants, a **benchmarking study of scenario-building** methodologies and best practices followed by entities developing their own scenarios has been carried out. This benchmark covered:

- | Three entities in the European Union
- | **Three entities in other countries**, but with comparable energy systems.

Recommendations in this section are linked to the best practices followed in other specific jurisdictions.

### 2.1 Benchmarking of best practices followed in other specific jurisdictions when developing scenarios

Institutions from various countries engage in long-term energy scenario development exercises. Gaining insight into their methodologies can help identify best practices for scenario building.

A clear understanding of these best practice elements will support proposals for additional TYNDP and ERAA scenarios. To achieve this, six scenarios developed by diverse entities with similarities to the European system have been selected for analysis.

#### 2.1.1 Benchmark methodology

##### **Selection of the scenario building process to be included in the benchmark**

The first step of the benchmarking task consisted in selecting the six scenarios to be analysed. The following criteria have been considered for the selection:

- **Country of origin:** The selection should include three scenarios from EU member states and three scenarios from non-EU countries

- **Variety of types of institution:** The selection should include scenarios developed by TSOs as well as by other types of organisations (NRAs, energy agencies etc.).
- **Purpose of the scenario:** The selected scenarios should address various goals such as resource adequacy, supporting long-term planning and the introduction of energy policies.
- **Data availability:** Sufficient information should be publicly available on the selected scenarios, in order to enable an in-depth analysis.
- **Geographical scope similarities:** Whenever possible, the selection should prioritise scenarios which, like the ERAA and TYDNP, represent several countries or interconnected regions.

The following scenarios have been selected for the benchmark:

Name of the scenarios	Country	Type of institution	Purpose of the scenario
Adequacy and flexibility assessment	Belgium	TSO	Resource adequacy assessment
Transition 2050	France	State financed energy agency	Explore prospective multi-sectorial scenarios that reach climate goals in 2050, with social, economic, and technical aspects
Futurs énergétiques	France	TSO	Describe possible scenarios for French electricity system
Future energy scenarios	United Kingdom	ISO	Exploration of strategic credible choices of pathways to net zero by 2050
Canada Energy Futures	Canada	Energy regulator	Explore possible energy (multi-sectorial) futures in Canada (National net zero and global net zero)
National Transmission Planning Study	USA	Research organisation in partnership with government	Resource adequacy assessment

### Definition of the reading guide

Before starting to read the reports, a reading guide detailing the information to be extracted was defined. The definition of this reading guide has ensured a uniform and efficient approach to understanding the methodology followed to build each of the six scenarios, including the assumptions made, data sources, guidelines followed and stakeholder engagement. The information that was retrieved from the reports is listed below:

- **General Description:**
  - o Publishing entity
  - o Objective of the report


- Frequency of publication
- Date of latest report
- **Scenarios:**
  - Number of scenarios/variants
  - Whether a central scenario is included
  - Name of scenarios
  - Objective of the scenario/variant or narrative of the scenario/variant
- **Modelling scope:**
  - Geographical scope and granularity
  - Other countries are modelled
  - Time horizon
  - Temporal granularity
  - Climate years used
  - Sectors modelled
- **General scenario building process:**
  - Existence of scenario development guidelines provided by a third party
  - General method to build the whole scenario and its narrative
  - Main drivers of the modelling for demand and supply
  - Stakeholders involved for the inputs of the scenario
  - Validation process of the scenario and stakeholders involved
  - Potential method to ensure targets are reached
  - Tools used for dispatch optimisation
- **Demand modelling:**
  - Methods to create demand levels, profiles and peaks
  - Tool used
  - Representation of the demand-side response (DDSR) in the modelling
  - Stakeholder involvement in the process
- **Supply mix modelling:**
  - Method to determine installed capacities and the supply mix
  - Tool used
  - Stakeholder involvement in the process
- **Grid modelling:**
  - Method to model the grid
  - Data sources used
- **Other data modelling:**
  - Method, tool and stakeholders involved for the modelling process of any other relevant data
- **Good practices:**
  - Communication events
  - Data transparency
  - Result validation

- Stakeholder feedback consideration
- **Changes from last edition**

All information for each of the reports can be found in the Excel file  
*ACER\_Artelys\_Benchmark\_Results\_23042025.xlsx*.

## 2.1.2 Key takeaways from the benchmark

This benchmark provided valuable insights into the methodologies used in long-term energy scenario development, data collection methods and stakeholder engagement processes. This section summarises key takeaways from the scenario benchmark.

Other findings of this benchmark exercise will be used in the various tasks ahead, to strengthen proposed methodologies and recommendations, and provide concrete illustrations. Throughout the report, references (marked with the sign  ) will be made to the benchmark.

### Nature of scenarios

Most reports do not feature a central scenario per se<sup>110</sup>. Nevertheless, in other cases, one scenario is still often used as a reference for comparisons between the scenarios. This scenario is either a “target-based” scenario, or a “trend-based” scenario:

- **A target-based scenario** is built based on the assumptions that national targets (usually NECP targets) are reached
- **A trend-based scenario** is built on current trends but can also include anticipated changes deemed most likely in the future, even if recent data show no clear indications of such trends.

Out of the six reports analysed, four present a **trend-based** scenario:

- **Future energy scenarios** (FES) by NESO in the United Kingdom (UK) with the “Counterfactual” scenario
- **Transition 2050** by ADEME in France with the “TENDANCIEL” scenario
- **Canada Energy Futures** by Canada Energy Regulator (CER) in Canada with the “Current measures” scenario
- **National Transmission Planning study** (NTP) by the National Renewable Energy Laboratory (NREL) and the US Department of Energy (DOE) with the “Reference scenario”

The two remaining reports do not present trend-based scenarios, their reference scenario are based on targets:

- **ADEQFLEX** by ELIA in Belgium with the “Central scenario”

---

<sup>110</sup> Out of the six reports analysed, only one report (**ADEQFLEX**) contains a scenario clearly identified as “Central scenario”.

- **Futurs énergétiques 2050** by RTE in France with the “Reference demand trajectory”

These reference scenarios, both target and trend-based, are consistently not the main focus of the reports, with **limited details** provided on their **methodology**. Their approach often differs from other scenarios (e.g. in **Future Energy Scenarios**, the Counterfactual scenario has no capacity expansion, unlike others), and in some cases the modelling is even simplified (e.g. in **Transition 2050**, the hourly electricity dispatch is not performed on the TENDANCIEL scenario).

### Geographical scopes

In Europe's interconnected energy system, modelling other countries beyond the primary focus is crucial for a robust analysis. All European reports<sup>111</sup> incorporate neighbouring countries in their modelling, while often with a lower level of detail than for the main country of study. The modelling assumptions for these neighbouring countries are often taken from scenarios developed by third parties (for instance **ADEQFLEX23'** relies on **ERAA**, **FitFor55** and **REPowerEU** assumptions for the countries other than Belgium, while **Future energy scenarios** rely on **TYNDP** and **TSOs** reports for market fundamentals assumption on neighbouring countries).

In most of the modelling exercises reviewed, the assumptions on the neighbouring countries are the same for all the scenarios and variants. Out of the four European reports, only **ADEQFLEX23'** contains scenarios with different assumptions on the neighbouring countries. In this case, the assumptions on neighbouring countries are made collectively (general rules on Europe as a whole rather than having country-specific assumptions). For instance, some scenarios of **ADEQFLEX23'** assume that all neighbouring countries will comply with reliability standards in 2027, while others assume that all neighbouring countries that have not yet implemented market wide capacity remuneration mechanisms will not take the necessary measures to meet their reliability standards. Installed capacities in other countries are therefore modified accordingly from sources mentioned above.

### Purpose of variants

Variants often reflect different levels of key scenario drivers on the demand (such as electrification or hydrogen development) or supply side. The definition of variants can be motivated by two main objectives:

- **Evaluating the impact of some drivers subject to a high level of uncertainty**. For instance, the French **Futurs énergétiques 2050** has three main scenarios on the demand (reference, deep re-industrialisation and sobriety) and four additional variants (electrification +, electrification -, least energy efficiency and hydrogen +). The scenario variant “Least energy efficiency”

---

<sup>111</sup> Including the United-Kingdom. The four European reports reviewed in the benchmark are **ADEQFLEX23'** (BE), **Transition 2050** (FR) **Futurs énergétiques** (FR) and **Future energy scenarios** (UK).

evaluates the impact of energy efficiency, including for example lower renovation rates than in the central demand scenario. Some drivers can reflect country specific energy contexts. For instance, on the supply side, the differentiation of scenarios in **Futurs énergétiques 2050** is mainly based on the level of investment in nuclear capacity—a factor of uniquely importance to France, and subject to uncertainty due to its political nature.

- **Explore broader possible futures**, with high-level assumptions that shape more detailed parameters. For instance, in **Canada Energy Futures**, scenario assumptions are based on national and global policy commitments toward net-zero targets. Similarly, in **Transition 2050** by ADEME, scenarios are based on societal attitudes towards energy transitions, amongst other high-level context assumptions.

### Stakeholder engagement

Stakeholder engagement is frequently emphasised in the reports. While the approaches and extent of engagement vary, feedback is always solicited. **Futurs énergétiques 2050** and **ADEQFLEX23'** have public consultations, **Transition 2050** has a scientific committee and interviews with citizens, **Future energy scenarios** and **Canada Energy Futures** have surveys, and the **National Transmission Planning study** has webinars open to questions.

Topic-specific workshops also appear to be common practices, with **Future energy scenarios**, **Futurs énergétiques 2050**, **National Transmission Planning Study** and **ADEQFLEX23'** having those types of workshops during the exercise. Although reports consistently state that stakeholder feedback is considered, only **Futurs énergétiques 2050**<sup>112</sup> and **Future energy scenarios**<sup>113</sup> provide details on which inputs were incorporated and how. In most cases, the range of stakeholders involved is broad, including public authorities, industry representatives, academia, private companies, utilities and others.

Some reports indicate that their findings must be submitted to or reviewed by other entities, or that their study was subject to external oversight. For instance, ADEQFLEX23' scenarios had to be submitted to the Minister of Energy and the Directorate General for Energy of the Federal Public Service for the economy. However, explicit guidelines governing these processes were only found in **Future energy scenarios**, with guidelines from Ofgem.

---

<sup>112</sup> [Futurs énergétiques 2050 – Bilan de la Phase 1 – Synthèse et enseignements issu de la consultation publique](#)

<sup>113</sup> [Future Energy Scenarios: ESO Pathways to Net Zero 2024 Stakeholder Feedback Document](#)

## 2.2 Design of an additional scenario for ERAA

ERAA scenarios are designed to assess resource adequacy in a robust manner. As required in ACER's methodology for the European resource adequacy assessment<sup>114</sup> and detailed in [Section 1.2.2](#) of this report, these scenarios should be aligned with the NECPs submitted by Member States. To ensure thoroughness, a wide range of uncertainties are considered, including climate variability captured through the modelling of up to 36 climate years and stochastic unavailability of assets due to random outages.

Another source of uncertainty is the speed with which the energy transition will be achieved. While lower-than-expected electrification may reduce adequacy concerns, delays in the development of new generation capacity could exacerbate them. This type of developments could affect adequacy outcomes, yet they are not currently explored within the ERAA framework, highlighting the need for an additional scenario that would consider such risks. In March 2025<sup>115</sup>, the European Commission published a report on the assessment of possibilities of streamlining and simplifying the process of applying a capacity mechanism. In the EC report, it is requested that ACER review the ERAA methodology, including the introduction of a "trends & projections scenario" notably based on historic data and current projections, that considers the actual progress towards delivering Member States' NECPS, including both renewable and demand targets. Following this, ACER requested ENTSO-E to submit an amendment proposal<sup>116</sup> that sets the additional scenario for ERAA as a central reference scenario. Therefore, the potential adequacy concerns raised in this scenario could be used by Member States to justify the introduction of a capacity mechanism.

The need for additional scenarios (not only for ERAA but also for TYNDP) was also identified by seven NRAs as one of the main issues concerning the ENTSO-E and ENTSG's scenarios developed for the ERAA and the TYNDP<sup>117</sup>. More specifically, some NRAs reported that the under-representation of some uncertainties in the scenarios limits their usefulness for robust decision-making, especially given the horizon of the scenarios. One NRA reported the need for scenarios which do not rely on the achievement of climate and energy targets. According to this NRA, this additional scenario is necessary for ERAA (given the fact that security of supply decision cannot be guided by the assumption of the achievement of the targets), but also applies to TYNDP scenarios<sup>118</sup>. Two NRAs reported that the current scenarios are too optimistic, and that the scenarios could be more realistic.

---

<sup>114</sup> [ACER - Methodology for the European resource adequacy assessment](#)

<sup>115</sup> [Report and proposal on streamlining procedures for capacity mechanism by the DG-ENER](#)

<sup>116</sup> [ACER's request for a proposal for amendments to the methodology for the European resource adequacy assessment](#)

<sup>117</sup> Source: Artelys' survey to NRAs. Despite the fact that the survey did not contain any specific question on the need for additional scenarios, seven NRAs highlighted it in their answers to the question: "What are in your view the main issues concerning the ENTSG's scenarios developed for TYNDP and ERAA?" (free text answer).

<sup>118</sup> In the same perspective, several respondents to the public consultation carried out by ENTSO-E and ENTSG on the gap-filling methodology, in the context of the TYNDP 2024, suggested presenting two versions of the 2030

This section provides proposals on the design of an additional scenario for ERAA that considers a near-term future largely driven by recent observed trends, rather than a forced alignment to national targets. The construction of this additional scenario shall focus mainly on assessing demand and energy supply evolutions, which may diverge from NECPs. As the following sections will demonstrate, the demand trends and installed capacity targets outlined in the NECPs appear ambitious when compared to recent developments, raising concerns about their achievability. Given the critical role of both demand and supply in ensuring resource adequacy, and the growing risk that these targets may not be met, it is essential to update projections on both fronts.

The section includes concrete examples demonstrating how to translate observed trends into projections, along with proposals on the relevant datasets to be used in the context of ERAA. Within the section, the structure begins by presenting the ideal methodology, assuming full data availability and is followed by a "Data Considerations" subsection, which discusses data limitations and proposes alternative approaches to address these challenges.

### 2.2.1 Insights from reports benchmark

As mentioned in the previous section, four of the studied reports present a trend-based scenario. The level of detail given on the methodology of those scenarios is quite low. Within those trend-based scenarios, methods tend to diverge, and often do not simply rely on a projection of actual trends, as can be seen in Table 4.

Report	Methodology
<p><b>Future energy scenarios</b></p>	<p>In the Counterfactual scenario, assumptions are made based on current trends. However, these <b>current trends</b> are <b>adapted</b>:</p> <ul style="list-style-type: none"> <li>- In some cases where uncertainty lies, for example regarding the outcome of a policy consultation that hasn't happened yet, the "least effort" outcome will be assumed, to reflect a worst-case possible option.</li> <li>- In other cases, some expected progress is assumed to be made when it is deemed certain enough. For example, home insulation is expected to improve even if current trends are not necessarily going in that direction.</li> </ul>

scenario: one based purely on NECP data and another adjusted to meet EU targets. This, they argued, would better illustrate the impact of the gap-filling adjustments.

This scenario variant (relying on the NECPs but without the gap-filling methodology) would have an intermediate level of ambition between the EU-target-compliant central scenario and a trend-based scenario.

<p><b>Transition 2050</b></p>	<p>The TENDANCIEL scenario is a projection of current trends. However, for a more realistic approach, this projection methodology considers certain <b>thresholds</b> (for example due to the saturation of an equipment market). This scenario is also said not to assume <i>a priori</i> that the policies voted that are not deployed yet will bring the expected effects.</p>
<p><b>Canada Energy Futures</b></p>	<p>The different scenarios of this report represent different policy directions. The “Current measures” scenario models the impact <b>all current policies</b>, as well as all policies which were announced prior to the report.</p>
<p><b>National transmission planning study</b></p>	<p>the Reference scenario is built with capacity expansion, similarly to the other scenarios. However, <b>the bounds of the capacity expansion</b> taken here are meant to <b>reflect current trends</b> rather than targets. On the demand side, the “Mid-Demand” trajectory from the Annual Decarbonisation Perspective report of Evolved Energy research<sup>119</sup> is used.</p>

**Table 4 – Methodologies of trend-based scenarios from the benchmark**

Data sources behind these scenarios are often quite vague. For example, reports indicate that they rely on:

- **Future energy scenarios:** “Stakeholder feedback, desktop research, published data, third party suppliers, government consultations and Ofgem survey results”
- **Canada Energy futures:** “Global scenario analysis produced by institutions, academia, industry, private forecasters and other relevant energy analysis are used to develop our own assumptions”

The following sections depict a proposal of methodology for an ERAA additional scenario. Whenever possible, the proposed approaches are supported by the methodologies used in the four scenarios mentioned above.

<sup>119</sup> [Evolved Energy research – Annual Decarbonisation Perspectives](#)

## 2.2.2 Projection of the demand

### 2.2.2.1 Introduction – Comparison of recent demand trends with ERAA 2024 demand forecasts

Having a clear understanding of recent annual consumption trends provides a strong foundation for projecting their future evolution. Comparing these trends with national targets also helps in designing a scenario that incorporates national trends. [Figure 29](#) and [Figure 30](#) below show the comparison of recent trends<sup>120</sup> with target-based demand projections<sup>121</sup> for Germany and France.

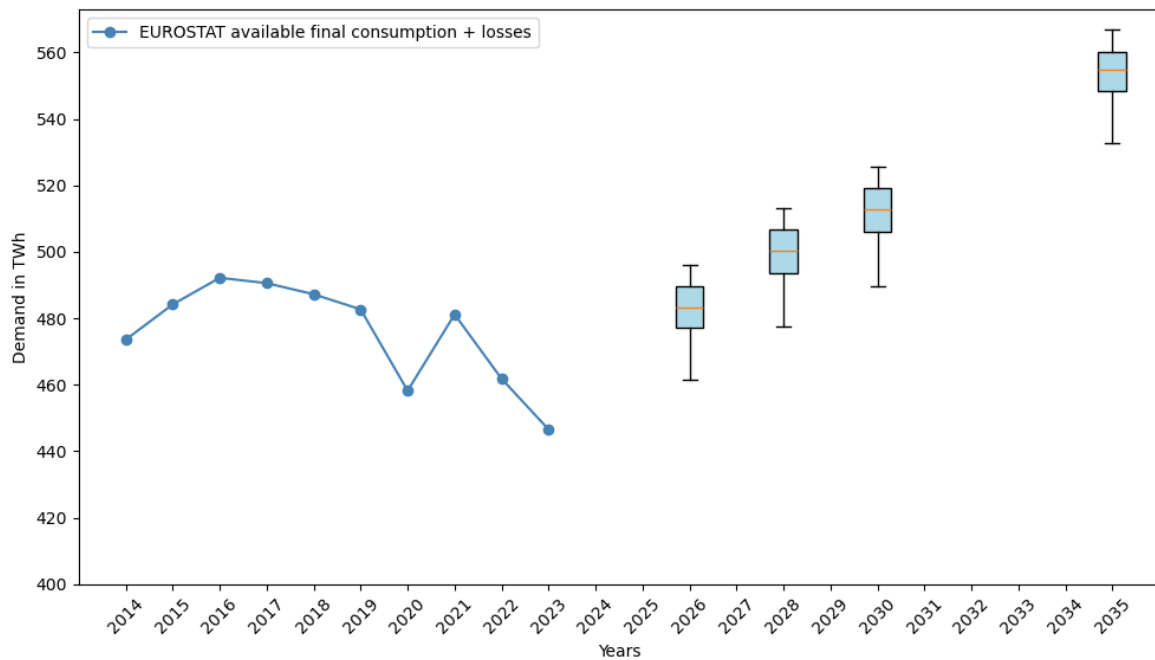


Figure 29 – Historical (EUROSTAT), and projected (ERAA 2024) electricity consumption in France

<sup>120</sup> **Historical consumption** (blue line): Data from EUROSTAT covering 2014 to 2023, based on the "Available final consumption" yearly, country specific dataset in addition to the "Losses" dataset

<sup>121</sup> **Projected consumption** (box plots): Consumption values for 2026, 2028, 2030, and 2035 from the ERAA 2024 Call-for-Evidence on Preliminary Input Data - Central scenario. The box plots represent the dispersion of the annual demand over the 36 climatic years.

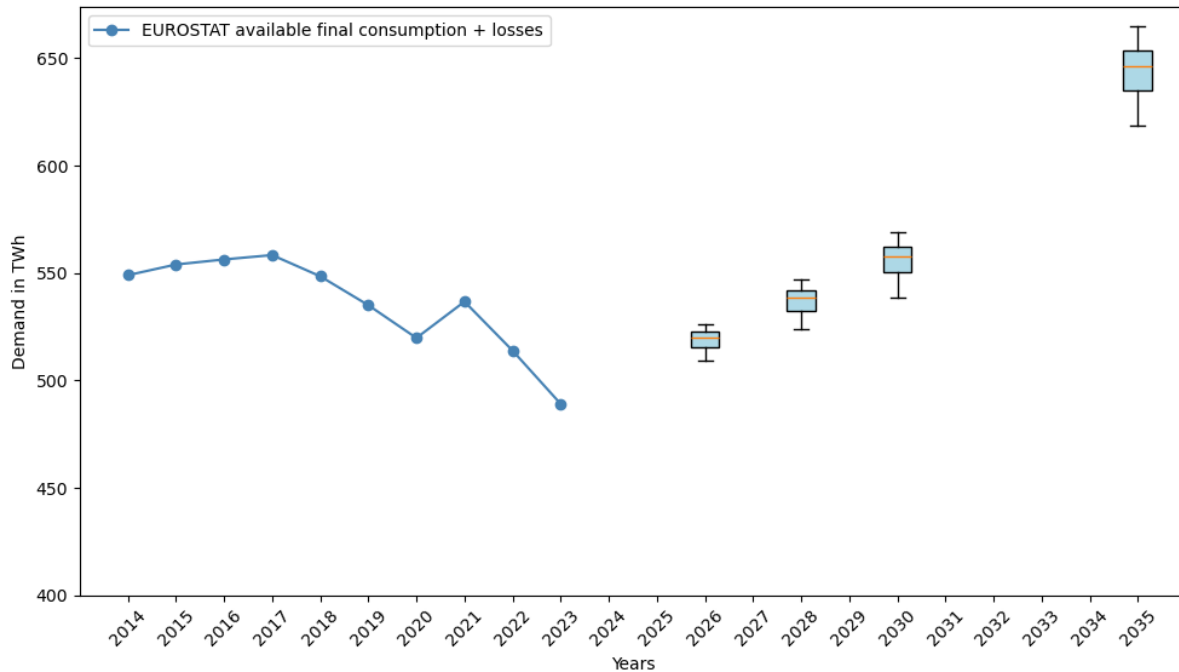


Figure 30 – Historical (EUROSTAT), and projected (ERAA 2024) electricity consumption in Germany

A comparison of current trends with scenario data based on NECP projections indicates a pronounced upward trajectory in projected electricity consumption relative to present levels.

Electricity consumption has been persistently declining in the last few years, which is in contradiction with the expectation of strong future demand growth in policy scenarios. This doesn't by default imply that the predicted shift in trend is not realistic, but it could also mean that its underlying drivers may not yet be visible in recent global consumption data.

These differences between historical data and target-based projections highlight the limitation of an approach that would consist in simply projecting global demand based on recent data. It would fail to capture the transformation of key sectoral drivers and their impact on future developments, which may underpin the anticipated shift in demand trends (e.g. Electrification of heating and road transport). Any straightforward extrapolation would instead suggest a continued decline, contradicting expectations of future evolutions based on policy drivers and technological developments.

Therefore, the methodology must integrate **sector-specific projections of key drivers** and their influence on electricity consumptions, ensuring a realistic link between demand evolution and these drivers. In other words, in order to **reflect current trends**, the projection will have to **take into consideration emerging signals** that indicate upcoming shifts, even if they are not yet clearly visible in aggregated historical electricity demand.

It is important to recognise that the variability observed throughout the years stems from several factors, including climate interannual variations (the alternation between warmer and cooler years, drier and wetter years etc.) and extreme events such as the Covid crisis and Russia's invasion of

Ukraine. To accurately extrapolate future trends, these **influences must at least partially be accounted for**.

Currently, Eurostat's historical consumption data are not weather adjusted. Although they also publish heating and cooling degree days (HDD and CDD)—which reflect deviations from a baseline temperature where no heating or cooling is needed— these indicators alone are not sufficient to develop robust weather-corrected consumption figures. Instead, the Demand Forecasting Toolbox (DFT) could be used to normalise the historical consumption data on constant climatic condition with advanced methodologies. It should be highlighted that the DFT algorithms are based on the reanalysis of historical consumption and historical climate condition at an hourly granularity (whereas many energy consumption climate correction approaches – such as the CDD/HDD approach – only work on an annual granularity).

As a further step, it could be interesting to include the impact of climate change based on trends. These developments could leverage on recent work carried out by Copernicus programme to integrate different climate change scenarios<sup>122</sup> in the Pan-European Climate Database (PECD 4). However, given the complexity of the models required to do so, and the second-order impact climate change is expected to have on short-term demand projections (e.g. trends built on the last five years and projected to the upcoming ten years) compared with the effects mentioned above, this further development should pragmatically only be implemented at a later stage.

## 2.2.2.2 Methodology to project demand

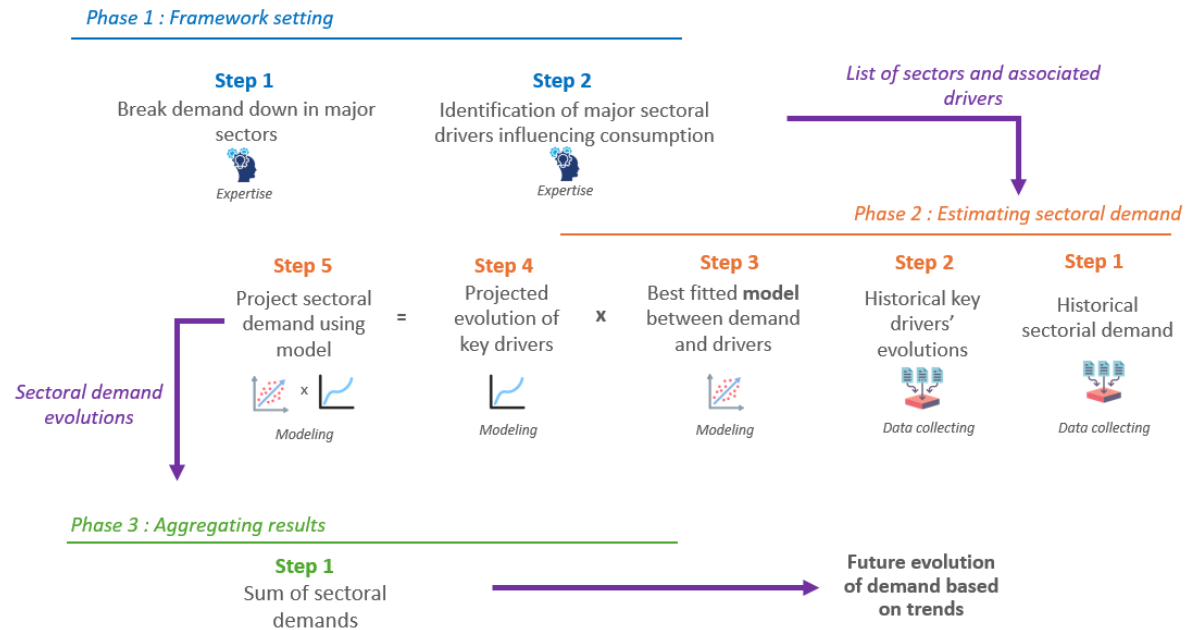
### Overview of the methodology

The methodology for estimating future demand relies on identifying the key consumption drivers, projecting their evolution based on observed trends, and assessing their influence on demand. Following the presentation of the ideal approach, alternative methods are proposed for steps that may

---

<sup>122</sup> The Shared Socioeconomic Pathways (SSP) is a new set of climate scenarios developed as part of the IPCC's sixth report (IPCC AR6). Compared with the RCPs used previously, the new SSP scenarios illustrate different socio-economic developments in relation to the different trajectories of greenhouse gas concentrations in the atmosphere. The four standard SSP scenarios are SSP1 2.6, SSP2 4.5, SSP3 7.0 and SSP5 8.5.

be constrained by data limitations. An overview of the methodology is provided in [Figure 31](#).



**Figure 31 - Overview of the methodology to project demand for an additional ERAA scenario**

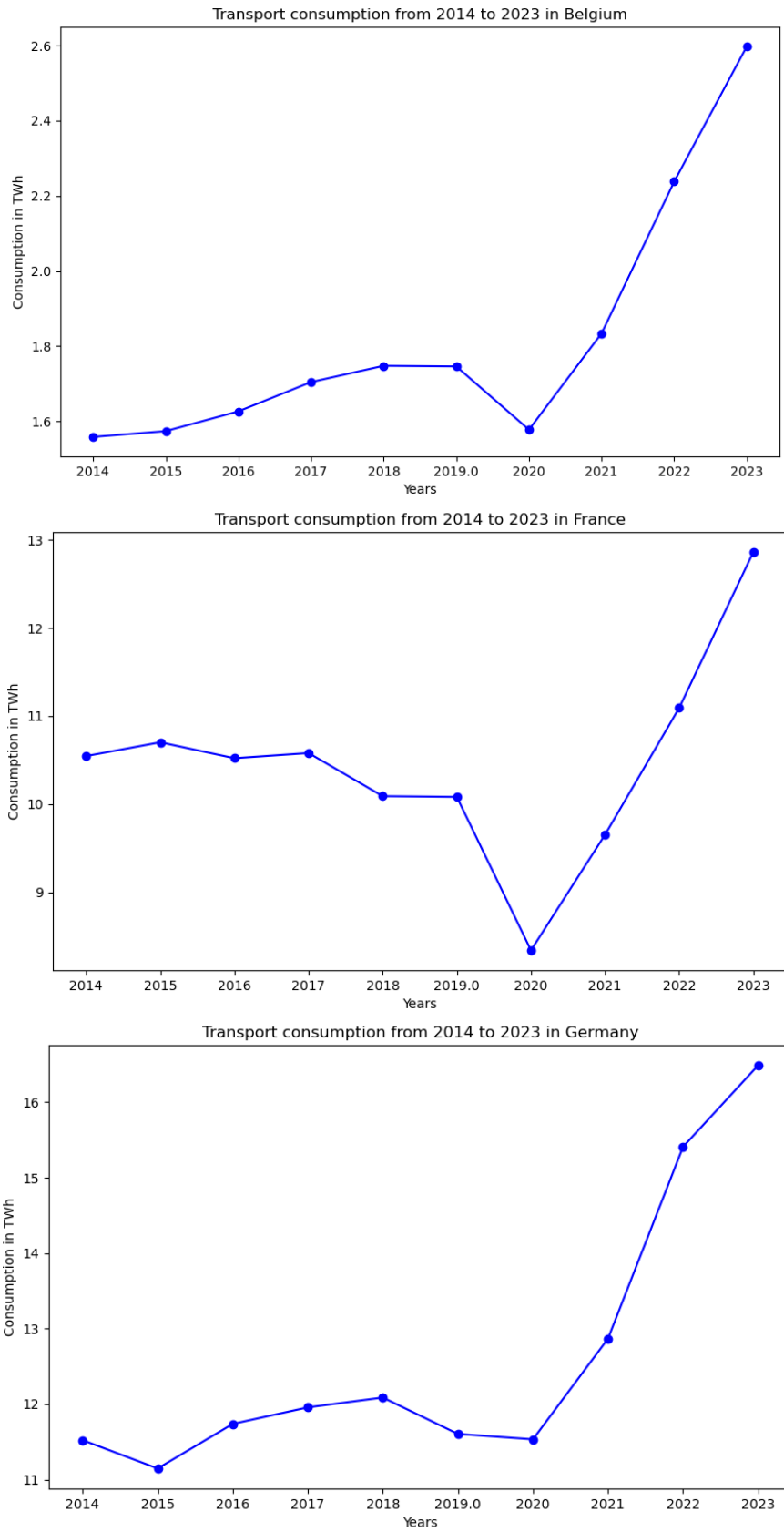
### Step 1 - Identification of key demand drivers over the past years for each sector

To estimate future levels of demand, sectoral electricity consumption trends need to be captured, and their underlying drivers identified. Demand is therefore segmented into four sectors:

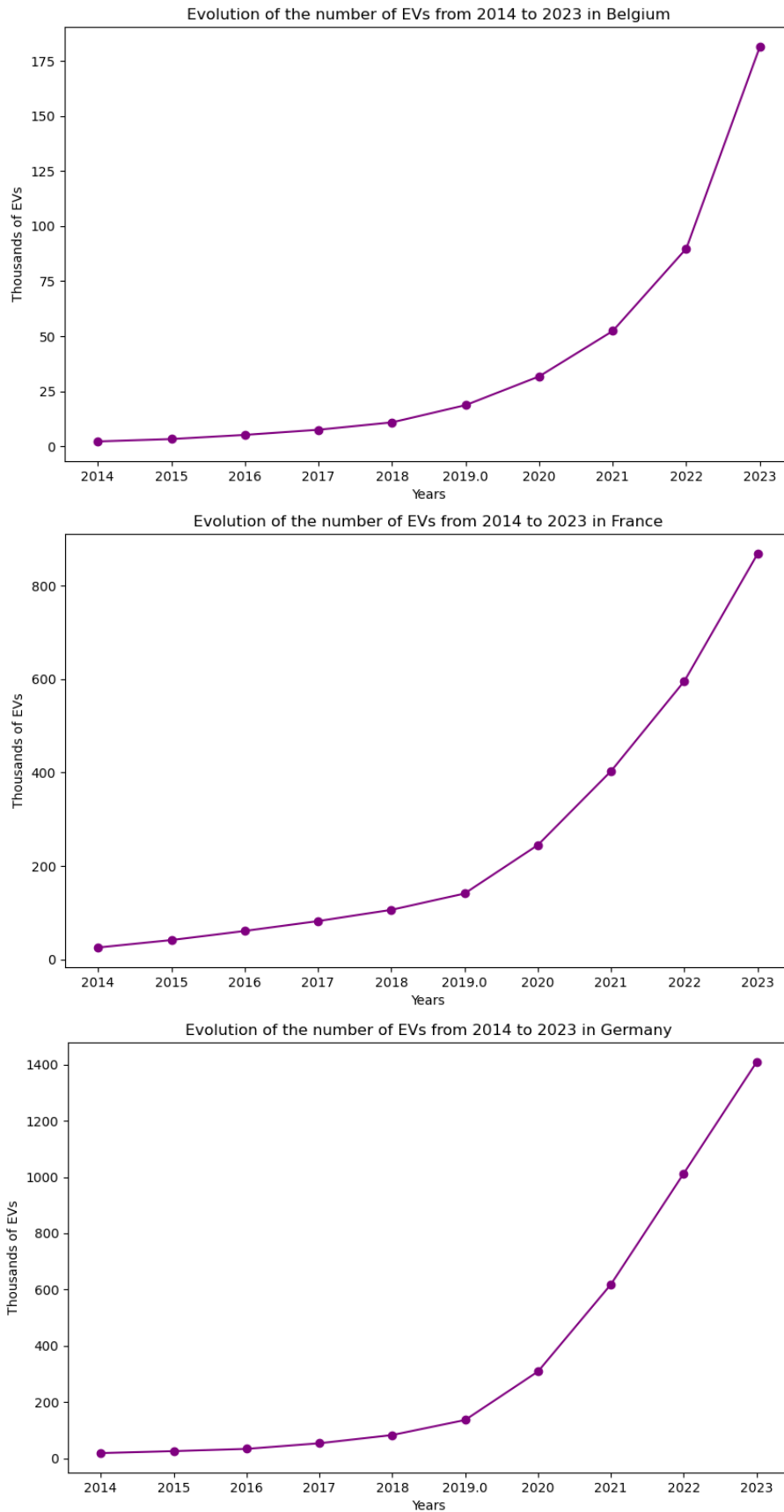
- Households
- Transport
- Industry
- Other

**In each sector**, key factors influencing the consumption should be identified. For instance, electricity demand in the transport sector is strongly linked to the number of electric vehicles (EVs).

As an illustration, [Figure 32](#) shows the electricity demand in the transport sector in Belgium, France and Germany, while [Figure 33](#) shows the evolution of the number of EVs. The electricity consumption in the transport sector and has been rising in recent years (except for 2020 which is as an evident outlier due to the Covid crisis and highlights the question of how to treat the outliers in the projections).



**Figure 32 – Historical electricity consumption in the transport sector between 2014 and 2023 (EUROSTAT)  
By appearance order in: Belgium ; France ; Germany**



**Figure 33 – Historical evolution of electric vehicles between 2014 and 2023 (EUROSTAT)**  
By appearance order in: Belgium ; France ; Germany

In a similar manner, other key drivers should be identified to capture the evolution of electricity consumption in other sectors. Key drivers for each sector are proposed in the table below (see Table 5).

Sector	Key drivers
Households	<ul style="list-style-type: none"> <li>- Number of heat pumps</li> <li>- Number of electric heaters</li> <li>- Energy efficiency</li> </ul>
Transport	<ul style="list-style-type: none"> <li>- Number of electric vehicles</li> </ul>
Industry	<ul style="list-style-type: none"> <li>- Share of industry in GDP</li> </ul>
Others	<ul style="list-style-type: none"> <li>- Number of data centres</li> <li>- Electrolytic hydrogen demand and electrolyser installed capacities<sup>123</sup></li> </ul>

Table 5 – Sectoral breakdown of consumption and their key drivers

## Step 2 - Construction of the model linking the key driver(s) to the sectoral electricity consumption

To be able to build a projection of consumption, **the relationship between these drivers and sectoral electricity consumption requires to be quantified**. The more drivers are identified, the more accurate the model will be and the better it will be able to represent different dynamics. For instance, in the residential sector, considering both the uptake and heat pump as well as energy efficiency efforts within the drivers enables to include in the model both an increasing and decreasing correlation between the drivers and sectoral demand. A model can be developed by correlating historical consumption data with historical evolution of the drivers. Model simplicity is essential to ensure results are easily interpretable. Therefore, as much as possible, linear models should be chosen to represent straightforward relationships.

If needed, to complement the approach, a more bottom-up one could be considered, using technical assumptions such as the average distance of an EV and its consumption per kilometre to estimate demand from the number of EVs. This could help in providing orders of magnitude to ensure the realism of results.

---

<sup>123</sup> Electricity consumption from electrolyzers is not embedded in the input demand. Instead, it is modelled through an electrolyser capacity and hydrogen demand. The associated electricity consumption is a result of the hourly economic optimisation. It is also mentioned in Section 2.2.3.

### Step 3 - Projection of the key drivers

Once the relationship between consumption and the evolution of key drivers has been estimated, consumption projections can be derived from the projections of these drivers.

The next step is therefore to **project the evolution of key drivers into the future**. This projection will serve as the foundation for future consumption estimates, making it essential to incorporate as much relevant information as possible while ensuring the methodology remains robust and applicable to all countries. Various projection methods can be employed. While a linear projection may be insufficient to capture acceleration or deceleration, **Holt's projection**<sup>125</sup> offers a suitable alternative for projecting key drivers. Holt's method captures long-term trends while placing greater weight on recent trends. This allows the projection to adapt more quickly to recent shifts or sudden changes in the trends. The approach involves smoothing the historical data, adjusting both the level and trend, and then forecasting based on this smoothed curve.

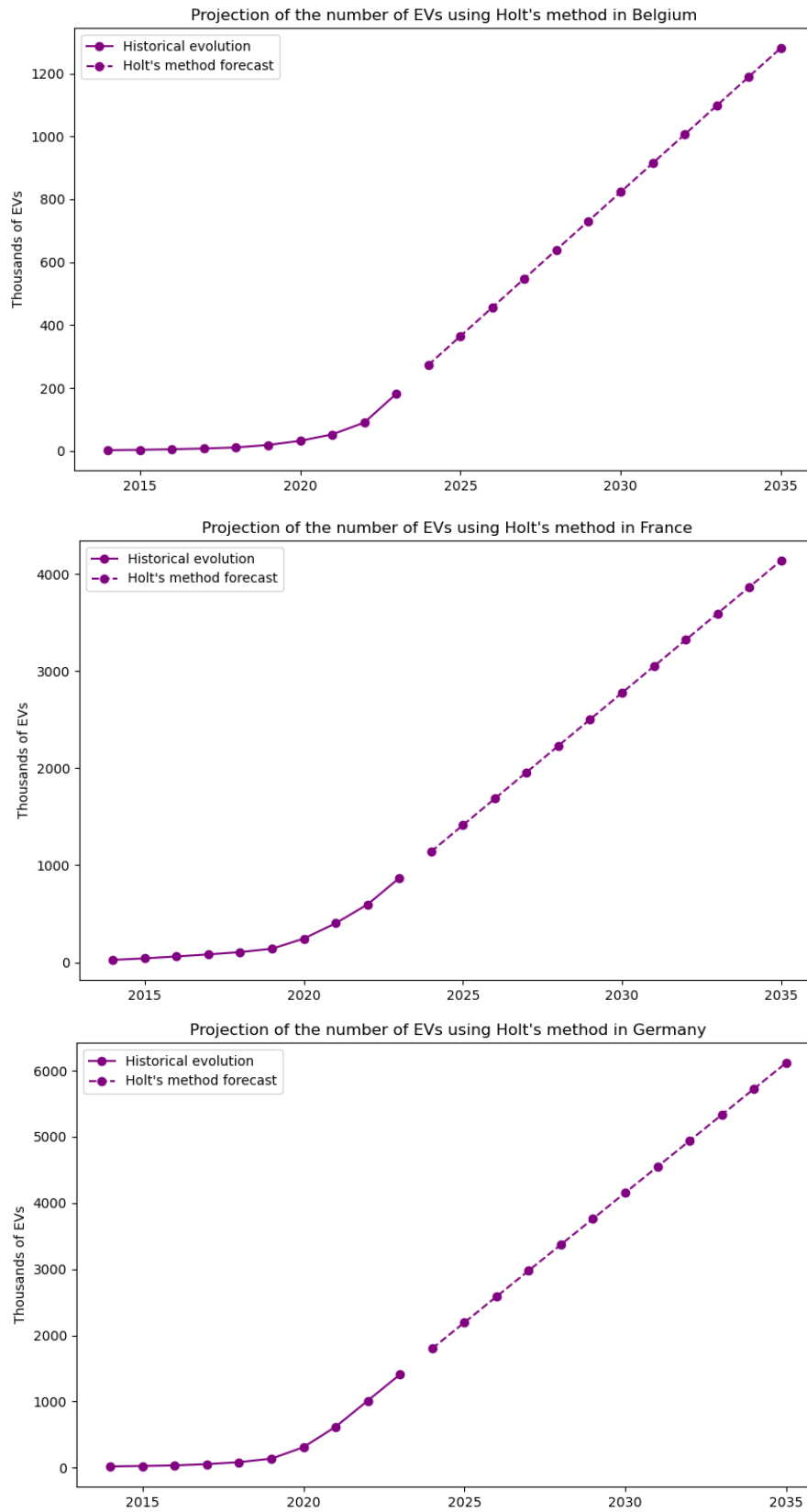
For instance, when projecting the evolution of EVs in Belgium, France and Germany using Holt's projection, the resulting trends are shown in [Figure 34](#). To assess the projection results, the result of Holt's projection are compared to national targets in the table below.

		Trend projection model	Reference for comparison
<b>Belgium</b>	2023	180 000 EVs <i>EUROSTAT</i>	
	2035	1,28 million EVs	2,6 million EVs <i>ADEQFLEX23' central scenario, based on NECP</i>
<b>France</b>	2023	868 000 EVs <i>EUROSTAT</i>	
	2030	2.7 million EVs	7.3 million EVs <i>Reference demand trajectory of Futurs Énergétiques, based on NECP</i>
<b>Germany</b>	2023	1,4 million EVs <i>EUROSTAT</i>	
	2030	4.1 million EVs	15 million EVs <i>2023 German Draft NECP<sup>124</sup></i>

Table 6 – Comparison of projection of EVs between proposed projection model and national targets

<sup>124</sup> [Germany's Update of the integrated national Energy and climate plan in 2023 – p 88](#)

<sup>125</sup> More details can be found about Holt's Linear smoothing and its implementation in python code [here](#).



**Figure 34 – Historical (EUROSTAT) and projected evolution (using Holt's method) of the number of EVs By appearance order in: Belgium; France; Germany**

As displayed in [Table 6](#), projections based solely on current trends diverge from national targets. In all cases, the projected model's results fall short of the ambitious targets, most notably in Germany, where the 2030 target is nearly four times greater than the projected level. However, consistently with the current uptake of EVs, the projected results still present rather significant increases in EVs compared to 2023 levels.

To ensure that the gaps are realistic, the questions of if and how to **incorporate policy assumptions** needs to be considered. For instance, there is an expected anticipatory impact for the announced European ban on the sale of new internal combustion engine passenger cars by 2035, which could increase the model's estimations, and therefore better align with the expected evolution.

Accounting for policies is delicate, and two main challenges occur when trying to incorporate policies into a trend-based scenario:

- A key question is whether announced policies should be assumed to materialise as planned. Here approaches differ:
  - o **Transition 2050** by ADEME assumes that announced policies will not achieve the expected outcomes
  - o **Canada Energy Futures** includes all announced policies as they are in their trends scenario (see [Benchmark 1](#)).
- Similarly, considering policies raises the question of whether to project a continuation of current efforts or assume no further progress. A more realistic stance would avoid systematically assuming full policy implementation. [Benchmark 2](#) gives an example of how the British report incorporates policies.
- A critical challenge is translating policies into quantified inputs. Other reports do not detail their approach on this matter. At the same time, it would appear evident that policies with measurable outcomes (e.g. technology bans) should be included with priority.

An approach for the ERAA additional scenario could be to consider **thresholds** when projecting key drivers, similarly to **Transition 2050** by ADEME. These thresholds could, in particular, represent policy assumptions. Short-term current policies could be categorized depending on their likelihood of being implemented. Policies that are highly likely to be implemented and backed by concrete measures can be treated as certain and used as a lower bound for the adoption of specific technologies when projecting the future evolution of key drivers. However, incorporating policy considerations in a systematic way is challenging without expert input, as estimating the likelihood of policy implementation is inherently uncertain.



## Canada Energy futures - CER

### *Policy considerations*

The report's timeline is split into a near-term future (2030) and a long term one (2030-2025).

#### **Before 2030:**

- | Include policies already in place:
  - If the policy ends prior to 2030:
  - Policy is assumed to be extended with the same intensity
  - Or policy is assumed to continue as if it continued to increase in strength
  - Or policy is ended
- | Include all announced policies that are not deployed yet

#### **After 2030:**

- | In the trend scenario, no further policies are assumed
- | In other scenarios, hypothetical policies are considered. These policies are modelled using an "aggregate cost of carbon" that represents the hypothetical suite of policies, regulations and programs that are assumed. The implementation in the model is done via an economy-wide carbon price that represents this aggregate cost of carbon.

#### **Benchmark 1 – Canada Energy futures Policy considerations**



## Future energy scenarios - NESO

### *Counterfactual assumptions*

#### **Policy delay:**

- | In the counterfactual scenario, it is assumed that the Future Homes Standard is not successfully implemented. In contrast, scenarios where the Standard is successfully applied prohibit the installation of fossil fuel boilers in new builds from 2025 onwards. To reflect a failure to meet the Standard, the counterfactual scenario assumes that 30% of new builds will still use gas boilers in 2025, with the full phase-out of these boilers in new builds delayed until 2031.

#### **Uncertain policies:**

- | The uptake of hydrogen for heating in the UK is highly dependent on policy support, which will be informed by the Government's decision in 2026. The Counterfactual covers the potential for low policy support and assumes no hydrogen for heat to be established.

#### **Benchmark 2 – Future Energy Scenarios policy consideration in counterfactual scenario**

#### Step 4 - Projection of the sectoral electricity demand

Once the projections of key drivers into the future have been established, using the best fitted model determined between consumption and drivers, **the projection of sectoral consumption can be calculated**. This method is to be led for each sector and drivers listed previously, in order to aggregate sectoral consumptions to achieve a national demand projection, based on current trends.

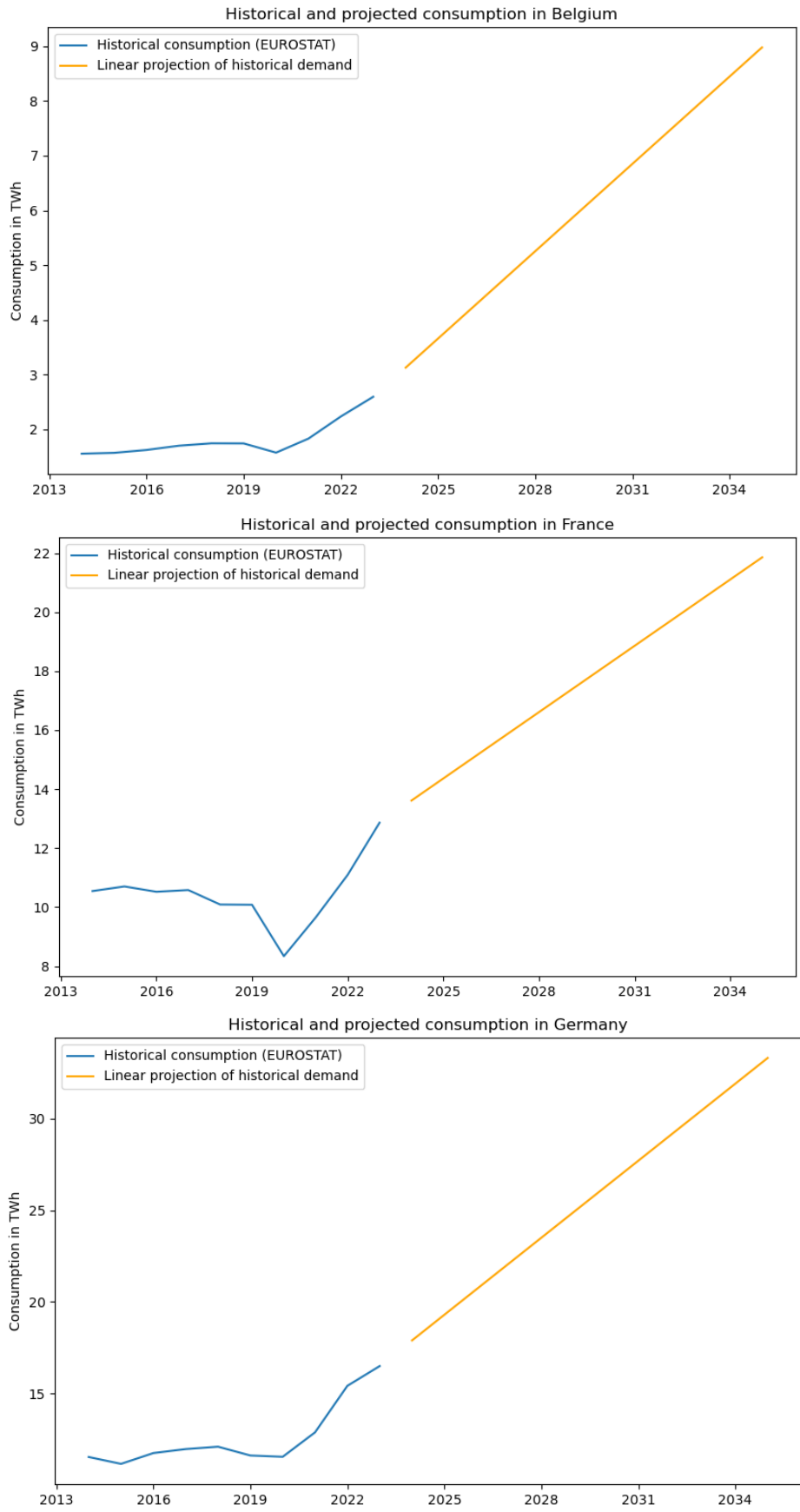
Building on the previous examples of Belgium, France and Germany’s transport sectors, electricity demand can be projected using a linear model based on the relationship between demand and EV adoption following the method outlined in **Step 2** (see [Figure 35](#)). To assess the realism of the results, the outcome of the projections are compared to sources aligned with national targets in the table below.

		Trend projection model	Reference for comparison
<b>Belgium</b>	2023	2,6 TWh <i>EUROSTAT</i>	
	2035	9 TWh	12,2 TWh <i>ADEQFLEX23’ central scenario</i>
<b>France</b>	2023	12,9 TWh <i>EUROSTAT</i>	
	2030	18 TWh	35 TWh <i>Reference demand trajectory of Futurs Énergétiques 2050, based on NECP</i>
<b>Germany</b>	2023	16,5 TWh <i>EUROSTAT</i>	
	2035	33 TWh	139 TWh <i>Langfristszenarien<sup>126</sup></i>

Table 7 – Comparison of trend projected and target transport sector electricity consumptions

Reflecting the differences in projected EV numbers, trend-based projected electricity consumption in the transport sector also vary from the values obtained in target-based scenarios. The gap in annual consumption illustrates the value of a trend-based scenario for adequacy assessment purposes, as sectoral differences in demand can cumulatively lead to substantial deviations from the central scenario.

<sup>126</sup> [Fraunhofer institute Langfristszenarien – Scenario TO45-Strom corresponding to 15 million EVs in 2035](#). This scenario is chosen because it is the closest to the NECP target (12 million EVs in 2030).



**Figure 35 – Historical transport consumption (EUROSTAT) and linear projection based on evolution of EVs**  
By appearance order in: Belgium; France; Germany

## Step 5 – Constructing hourly profiles

Electrical demand is characterised by both its overall level and its hourly profile. In scenarios with ambitious flexibility development, the demand profile is expected to evolve, with some consumption shifting from peak periods to times of lower electricity prices.

In the central scenario, the hourly demand profiles are built using the DFT tool for most of the countries. For sake of consistency, the same tool should be used to generate the hourly profiles of the additional scenario.

Ideally, the flexibility parameters (notably the price-sensitive ratio for electric vehicles, heat-pumps and out-of-market batteries<sup>127</sup>) used to generate the hourly demand profiles and the flexible share of the demand should be adjusted compared to the central scenario, in order to reflect the current demand flexibility development trends. However, the difficulty of this approach is that the current value of the price-sensitive ratio cannot be directly observed or measured (as opposed, for instance, to current demand or current installed capacity of the different technologies). Therefore, determining quantitatively the current value of the flexibility parameters would require complex models to analyse consumers' behaviours and deduce from it the level of flexibility of the consumers. A simpler alternative would consist in not trying to quantify the current value of the flexibility parameters based on the analysis of consumers current behaviours etc., but instead to rely on expert intervention to determine, based on the value of these parameters in the central scenario, current-trend reasonable levels to be used as inputs in the DFT tool.

### 2.2.2.3 Data consideration

The table below provides a proposal for data sources which could be used to implement the previously proposed approach on all sectors. Data gaps are highlighted in red.

**Table 8 – Summary of available data sources for consumption projection**

	Sector	Data	Source – Link	Source – Name	Timeline
Demand	Households	Household electricity consumption per usage (non-weather corrected)	<a href="#">Households – Electrical demand per energy use</a>	EUROSTAT	2013 - 2022
					2023 & 2024
		Number of heat pumps	<a href="#">Ambient heat consumption in TJ for household space heating and cooling</a> <sup>128</sup>	EUROSTAT	2013 - 2022

<sup>127</sup> As defined in ERAA 2024 methodology report ([link](#)), page 16.

<sup>128</sup> Number of heat pumps and heat pumps consumption in TWh is not directly available in EUROSTAT. But it can be deduced using ambient heat consumption in TJ and technical assumptions on heat pumps.

			<a href="#">Heat pump unit stock in market report</a>	European Heat Pump Association (EHPA)	2023
			<a href="#">Heat pump unit stock in market report</a> <sup>129</sup>	European Heat Pump Association (EHPA)	2024
		Electric heaters	<a href="#">Electricity consumption (without heat pumps) for households</a>	EUROSTAT	2013 - 2022
					2023 & 2024
		Fossil fuel boilers	<a href="#">Space heating and cooling consumption without electricity</a>	EUROSTAT	2013 - 2022
					2023 & 2024
		HDD & CDD	<a href="#">Cooling and heating degree days</a>	EUROSTAT	2014-2023
					2024
		Transport	Electricity consumption	<a href="#">Final consumption – Transport sector – Electricity</a>	EUROSTAT
					2024
	Number of EVs		<a href="#">Number of passenger cars by type of motor energy</a>	EUROSTAT	2014-2023
			<a href="#">Alternative fuelled passenger cars and vans</a>	European Alternative Fuels Observatory	2024/2025
	Industry	Electricity consumption	<a href="#">Electricity consumption split by activity (55 activities, including Iron &amp; steel manufacturing, cement manufacturing, etc..)</a>	EUROSTAT	2017-2022
					2023 & 2024
	Others	Data centres	<a href="#">Energy consumption in Data Centre in the EU</a>	Joint Research Centre (JRC)	2022
					2023 & 2024

<sup>129</sup> Note that the data only concern 21 countries (18 of which are EU Member states).

**EUROSTAT** serves as a reliable and comprehensive data source. Whenever possible, this source should be prioritised, to ensure consistency across the calculations. However, in many cases, data is only available up to 2022, which is problematic when it comes to building a trend-based scenario. When EUROSTAT fails to provide the needed data, an additional source can be combined (e.g. using the European Heat Pump Association data for most recent figures).

Some data is also not available at all in EUROSTAT. For instance, little information is available in EUROSTAT on data centres and a low level of detail is also available in the industry sector. These data gaps present an opportunity to advocate for greater data availability at the European level. For instance, [the Joint Research Centre](#) article “Energy Consumption in Data Centres and Broadband Communication Networks in the EU” (see [Table 8](#)) provides recommendations for improving data collection and modelling regarding data centres. The report calls on governments, statistical agencies and companies to develop standardised definitions, and improve data availability. It also emphasises that the lack of detailed historical data in previous studies makes it difficult to assess the robustness of any analysis on this subject.

Finally, some sources do not cover extra-EU countries (which are yet modelled in the ERAA). For instance, the electricity consumption of the transport section in the UK is only available up to 2019. As another example, no information at all is given on the number of EVs in Montenegro. In this case, an alternative method to project sectoral method may be necessary. It can be required from Member States to provide estimations of additional sectoral demand at specific time steps. Regression techniques can then still be used to interpolate between time steps.

When available data does not permit establishing a correlation between sectoral demand and a specific driver, the relationship can be approximated by assuming a specific consumption value. For example, if data linking electricity consumption to the number of datacentres are lacking, the approach can be reversed: a specific consumption per datacentre is assumed, is applied to the driver’s evolution, and the resulting consumption is then incorporated into the sectoral demand.

Tailoring estimations of demand depending on data availability has also been encountered during the benchmark of other reports (see [Benchmark 3](#)).



## National Transmission Planning Study - NREL

### *Estimating annual demand*

Demand trajectories are based on a report from Evolved Energy Research company. Demand is split into 4 sectors: Residential, Commercial, Transport, Production.

**Four different methods are applied, each with progressively lower data requirements.** The methods with minimal data needs are used in cases where comprehensive data is unavailable or when the nature of the end use under study is too heterogeneous or lacks the necessary measurements for more detailed analysis:

- | **Method A:** The most explicit representation of energy demand. It has the highest data requirements. This method uses a “service demand” that is calculated as a function of technology stock, service demand modifiers and energy carrier utility factors, themselves modelled using other assumptions
- | **Method B** is the same as method A, expect that service demand cannot be calculated, so energy demand of the subsector is used as a substitute input for service demand
- | **Method C:** This method replaces the stock term in energy demand with a service efficiency term as an exogenous input

#### Benchmark 3 – National Transmission Planning Study methodology for the estimation of annual demand

## 2.2.3 Projection of the newly installed capacities

### 2.2.3.1 Introduction – Comparison of recent trends with ERAA 2023 levels

Similarly to demand, having a clear understanding of how recent trends articulate with the levels projected in recent ERAA editions provides a sound basis for proposing a methodology to build a scenario that incorporates national trends while still heading in the same direction as NECPs. The figures below illustrate recent trends in installed capacities, which includes:

- **Historical installed capacities:** Data from ENTSO-E’s transparency platform from 2015 to 2025.
- **Projected installed capacities:** Data from ERAA 2023 in 2028, 2030 and 2033.

For illustrative purposes and since their contrasting energy mixes offer two distinct examples, the example below is focussed on installed capacities in France and Germany (see [Figure 36](#) and [Figure 37](#)). Only key technologies that are common across the database are displayed, meaning that geothermal, waste, biomass, fossil peat, biofuel and other renewable and non-renewables are excluded.

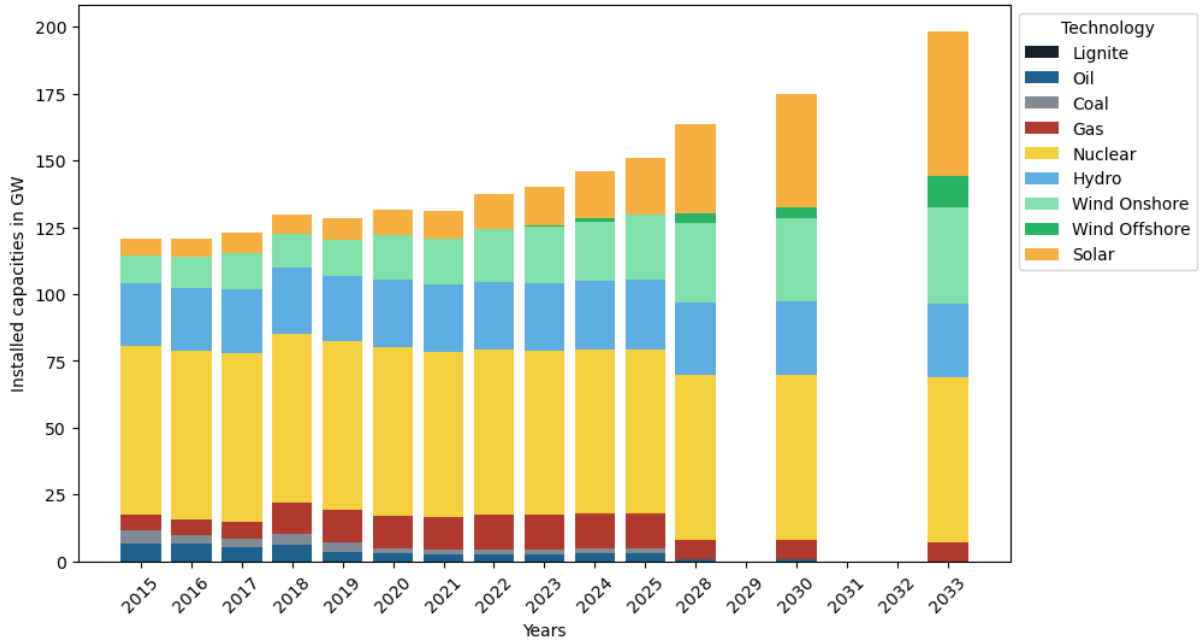


Figure 36 – Historical (ENSTO-E’s transparency platform) and projected (ERAA 2023 – central scenario) installed capacities in France

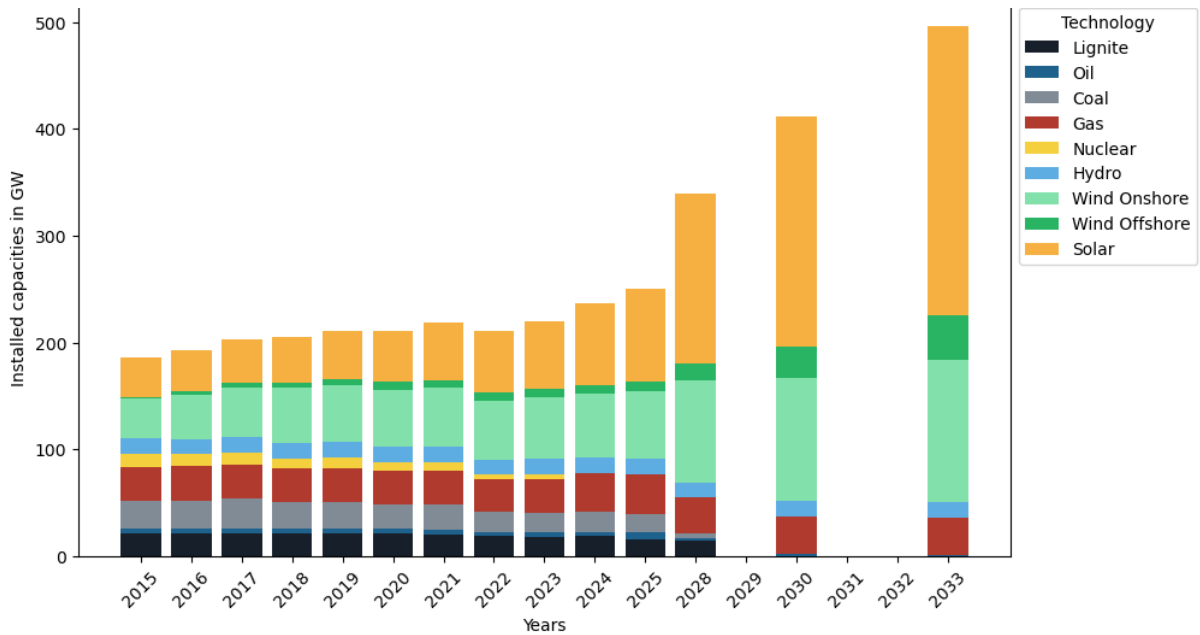


Figure 37 – Historical (ENSTO-E’s transparency platform) and projected (ERAA 2023 – central scenario) installed capacities in Germany

While the expected decline in French gas capacities is not reflected in recent trends, the **direction of other recent trends largely aligns with the ERAA capacity mix assumptions that are based on national targets**, particularly in the expansion of renewable capacities.

Unlike demand, installed capacities projected in recent ERAA editions are overall evolving in the same direction as the recent trends. However, the **development speed of some technologies evolves (either accelerates or decelerates)** over time. For instance, Germany's installed solar capacity is supposed to rise from approximately 85GW in 2024 (according to ENTSO-E's transparency platform) to 159,7GW in 2028 (according to ERAA 2024 scenario), which would suppose around 18GW of additional capacity by year. For comparison, the annual capacity increase between 2021 and 2024 is 8GW/year<sup>130</sup>. Note that capacity numbers vary depending on the source (for instance in the Bundesnetzagentur's report<sup>131</sup>, 99.8GW of solar capacity is reported for 2024). Whether these surges will actually materialise will depend on the **scale and speed of project deployments** in the different sectors. A **limited roll-out of renewable installed capacities** is expected in this additional ERAA scenario based on trends.

Different methodologies could be built to extrapolate the recent trends, such as:

- | **Linear interpolation of the total installed capacities.** However, this projection method would fail to represent any acceleration (or deceleration) in the development of capacities. Indeed, the linear extrapolation of the installed capacities would represent a constant development speed of the different technologies compared to the recent years.
- | **Linear interpolation of the newly installed capacities.** This approach would enable to represent acceleration or deceleration in the deployment speeds of the different technologies. However, the linear interpolation of the newly installed capacities would be a quadratic extrapolation of the total installed capacities, which would also be mathematically less robust than a linear extrapolation. Moreover, similarly to a linear interpolation of total installed capacities, this approach would fail to represent some key fundamental drivers, such as the evolution of regulation or support schemes, limitations on the connection to the network or industrial chain limitations preventing installations from exceeding a certain speed.

In the light of the observations made on the above examples, and for the reasons set out above, a purely mathematical projection (based on extrapolation of the recent past, either linear or quadratic) does not seem to be suitable and robust for constructing a trend scenario for the supply side.

For these reasons, the methodology proposal described below does not consist in a pure mathematical extrapolation of the recent trends.

---

<sup>130</sup> These analyses rely on the assumption that the data from ENTSO-E's transparency platform cover the exact same scope as the input parameters of ERAA scenarios.

No verification of this compliance has been carried out as part of this project. Nevertheless, preliminary analyses have highlighted differences between the installed capacities reported in ENTSO-E's transparency platform and those reported by Eurostat (table name: nrg\_inf\_epc). For instance, in the Netherlands, ENTSO-E's transparency platform reports 22.59 GW in 2023 and 24.261 GW in 2024, while Eurostat reports 22.174 GW (AC) in 2023 and 24.3 (DC).

<sup>131</sup> [Genehmigung – Des szenariorahmens für den Netzentwicklungsplan Strom 2025-2037/2045](#)

## 2.2.3.2 Methodology to project installed capacities

### Introduction

The basis of the methodology described here is to analyse the pipeline of projects currently under development (number and size of projects, development stage etc.), and to determine, based on the pipeline of projects and on typical development durations for the different type of projects an expected value of additional capacities to be commissioned at the different horizons.

This methodology could be applied to different types of electricity generation technologies (including solar, wind, nuclear, coal, gas, hydropower), as well as to the different storage and hydrogen generation (electrolyser) technologies. The description below aims to cover the widest range of technologies and is therefore generic. However, this methodology could be customised to better represent techno-specific constraints or dynamics.

This methodology is particularly relevant for the shorter-term horizons, for which the dynamics are largely driven by the trends observed in the recent years and by the projects already under development. The validity of the approach for the longer-term horizons of the ERAA will have to be further assessed in Proofs of Concepts on real data. These horizons might be technology-specific, as the timeframes for project commissioning can vary significantly between technologies. For instance, for technologies with long development cycle, such as interconnection projects or nuclear power plants, the current project pipeline can remain relevant for the next 15-20 years. However, for projects such as wind or even more solar, which have shorter development lengths, the approach will only work for the next 5 to 10 years.

One of the key challenges to implement an approach based on the analysis of the pipeline of projects under development is to have access to the data on the projects under development. This question is further elaborated in section [2.2.3.3 Data consideration](#). In the rest of this section, it will be assumed that the data are available to implement this approach.

The proposed approach can be decomposed into two steps:

- | Step 1: descriptive statistics on the evolution of the pipeline of projects over the recent years, to determine probability distributions for project completion and project commissioning times as a function of project characteristics and level of progress.
- | Step 2: determination of an expected capacity to be commissioned at the different horizons, by projecting the functions calibrated in step 1 on the projects currently under development.

### Step 1: descriptive statistics on the evolution of the pipeline of projects over the recent years

The objective of this step is to build probability distribution on the chances for a project to be completed by a given horizon, based on properties of the project and on its status. To do this, descriptive statistics models will be developed on the evolution of the project pipelines over the recent

years. In essence, the goal is to **forecast what proportion of projects will be commissioned or abandoned and anticipate possible delays.**

As mentioned above, it is considered here that data availability enables to know the current project pipeline for technologies. The method begins by segmenting the current project pipeline into distinct statuses. The status suggested here mirror those present in the **International Energy Agency (IEA) hydrogen production project database**<sup>132</sup>.

- Conceptual
- Feasibility study
- Construction
- Operational

For each status, the aggregated capacity in MW of projects is associated.

Descriptive statistical models can be used on historical pipeline evolutions to ascertain transition probability between status. The analysis would focus on the number of projects that entered the pipeline and reached the operational stage in contrast to the number of projects that were abandoned, and the different timelines between the statuses. In practice, this means that the statistical models applied to historical pipelines would determine:

- The average percentage of capacity in a given status (e.g., Conceptual) that ultimately reach the operational phase.
- The average time required for this transition.

It could be considered that to enhance the link of the method to current trends, the amount of **policy support at a national level** could be incorporated. The probabilities around the share of capacities to reach completion is influenced by the broader policy environment (e.g., the presence of funding is directly linked to policy engagement). This factor would be integrated into the probability distributions by linking the model's probabilities to current levels of policy support and projecting that enhanced policy support onto the probabilities. However, incorporating these elements would increase the complexity of the method and require additional data, which might be challenging to implement. Strong policy incentives will increase the proportion of capacities within a status to reach operation stage while weak government support will lower it.

Basing a projection of installed capacities on project pipelines is similar to what is done for grid capacities in **Future energy scenarios** (see [Benchmark 4](#)).

---

<sup>132</sup> The IEA hydrogen production project database can be downloaded [here](#). This Excel file lists all electrolyser projects in Europe, providing various characteristics, including the project status.



## Future energy scenarios - NESO

### *Estimating installed capacities and grid capacities*

#### **Production:**

- Installed capacities are determined through capacity expansion, incorporating both project pipelines and national targets as constraints
- To reflect the context of each pathway, delays are applied to a subset of projects within a technology category, with the extent of delays varying by pathway. For example:
  - *Electric engagement* pathway considers a 1- or 2-year delay on a subset of projects
  - *Hydrogen Evolution* pathway considers 2- or 3-year delay on a subset of projects

#### **Grid:**

- All potential projects and their expected commissioning dates are identified
- Each project is assessed against political, economic, social and technological factors to determine its feasibility under different pathways
- If the project does not meet a minimum criterion defined:
  - Either the projected is considered not delivered in this pathway
  - Either a delay of commissioning is considered

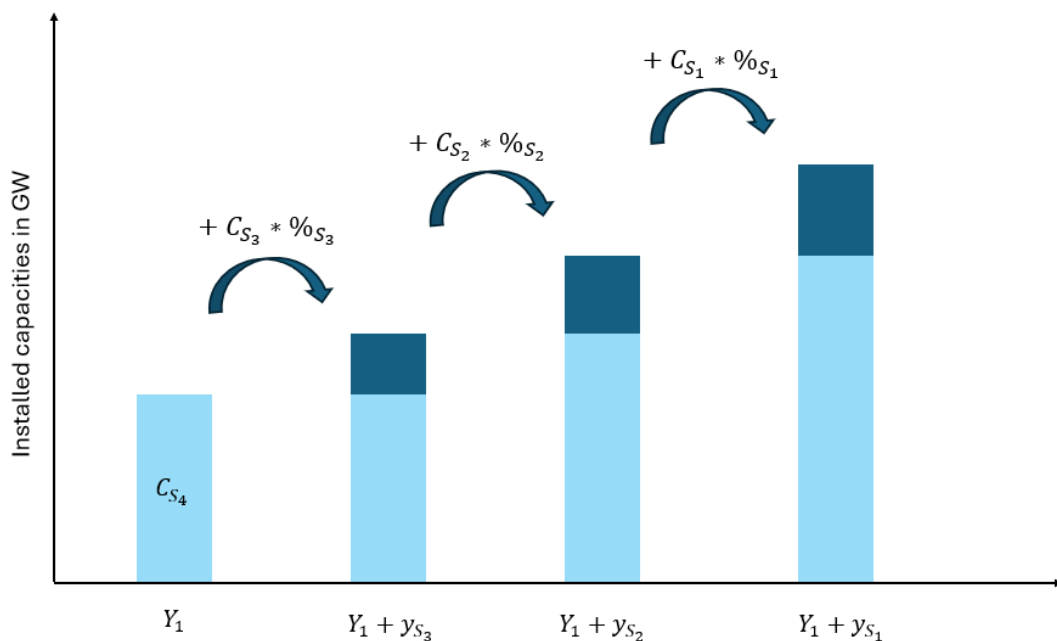
**Benchmark 4 – Future energy scenarios' methodology to estimate future installed capacities and interconnections**

## Step 2: determination of an expected capacity to be commissioned at the different horizons

In this step, the transition probabilities and timelines developed in **Step 1** are applied to the current project pipeline to forecast future installed capacities. By attributing the derived shares to the capacities at the different statuses and combining these with the estimated average time to commissioning, a projection of future capacities along the timeline can be generated. For instance, let:

- $Y_1$  be the first year of the study
- $Y_n$  be the last year of the study
- $S_1, S_2, S_3, S_4$  be the project statuses before completion, respectively, Conceptual, Feasibility study, Under construction and Operational
- $\%_{S_1}, \%_{S_2}, \%_{S_3}$  be the average shares of capacity to reach completion in each status
- $C_{S_1}, C_{S_2}, C_{S_3}, C_{S_4}$  be the capacities included in the different statuses
- $y_{S_1}, y_{S_2}, y_{S_3}$  be the average times for a project to move from its status to completion

As shown in [Figure 38](#), the future installed capacities for a given technology are estimated by adding the shares of capacities to reach completion at the appropriate time steps. Between each time step, installed capacities can be interpolated to have a continuous evolution of capacities.



**Figure 38 – Illustration of the methodology to project installed capacities for ERAA additional scenario**

It is important to note that the dynamics of the pipeline vary by technology. Applying this approach gives accurate estimations for the near-term future. However, if the longest average timeline-for instance from conceptual to commissioned status- is shorter than the study period (meaning that  $Y_n > Y_1 + y_{S_1}$ ), the model must account for the **continuous flow of new projects entering the pipeline** in order to accurately project capacities throughout the entire timeline. The following approach could address this issue: First, the previous method is applied on the current project timeline to project installed capacities from  $Y_1$  to  $Y_1 + y_{S_1}$ . Then, from  $Y_1 + y_{S_1}$  to  $Y_n$ , the installed capacities are

extrapolated, based on the evolution of installed capacities between  $Y_1$  and  $Y_1 + y_{S_1}$ . This extrapolation inherently incorporates any acceleration or deceleration effects that are already reflected in the pipeline's timeline, thereby ensuring that these dynamics are captured, unlike a projection based on current levels.

### 2.2.3.3 Data consideration

Ideally, the methodology laid out above should be carried out on all generation projects, including hydrogen and storage technologies, for each European country. A publicly available European centralised database listing all potential future projects with the right criteria does not seem to exist at the moment.

The information on the projects currently under development may be subject to business confidentiality, which explains why this information is currently not easily accessible in a unified format. Nevertheless, TSOs are among the best-placed players to have access to this confidential information about projects under development, even before this information is made public, because of the grid connection requests that developers have to make. These data may be supplemented by connection requests provided by the DSOs (especially for distributed resources) and potentially with environmental authorisations to be provided by the Member States. If the approach relies on confidential data, a particular attention will have to be given to ensuring that the aggregated projections published in the scenarios do not compromise the confidentiality of individual project data.

The following data sources could be explored:

#### | Electricity generation technologies:

- Publicly available sources:
  - ENSTO-E's transparency platform provides current installed capacities.
  - WindEurope's *2024 Statistics and the outlook for 2025-2030* report<sup>133</sup> provides estimations of future wind installed capacities and auctions & tender information by country.
  - SolarPower Europe's *EU Market Outlook for Solar Power 2024-2028* report<sup>134</sup> provides statistic on EU solar investments in 2024 as well as market prospects for 2025-2028 period.
- Other sources to be explored:
  - The list of **grid connection requests** could be required from TSOs and DSOs.
  - Results of **auctions** and **tenders** for support schemes (contract for difference or granted tariffs for renewable capacities under development, capacity contract awarded).

<sup>133</sup> WindEurope (2025): 2024 Statistics and the outlook for 2025-2030 – [Link](#)

<sup>134</sup> SolarPower Europe (2024): European Market Outlook for Solar Power 2024-2028 – [Link](#)

NB: some data of SolarPower Europe are only accessible to its members.

| **Hydrogen technologies:**

- **IEA hydrogen production project database<sup>135</sup>** all future hydrogen projects in Europe, per country. This database includes characteristics such as project status, commissioning date and capacities of electrolyzers.
- List of EU energy Projects of Common and Mutual Interest
- This list could be consolidated with grid connection requests.

- **Storage technologies:**

- The **JRC** has a [European Energy Storage Inventory](#) where they list storage projects in European countries. Projects are split depending on the technology (mechanical, electrochemical, thermal and chemical), and their status (operational, announced, under construction, permitted, inactive). Projects are all merged depending on these characteristics and therefore not presented as individual projects with their own characteristics. This database only provides information on large-scale projects, not distributed resources.
- List of EU energy Projects of Common and Mutual Interest (for the eligible types of projects)
- ENTSO-E's [TYNDP 2024 storage projects sheets](#) also provides additional information (capacity, location and status) for the storage projects eligible to the PCI status.

It is possible that not all the required data to fully implement the methodology will be available. When possible, the original methodology should be prioritised; however, simplifications may be necessary if data gaps emerge. For example, if historical data do not allow for robust estimates of completion shares in certain statuses, a conservative approach may be to assume that projects in that status either all proceed to commissioning or are all abandoned (e.g., all projects in the conceptual phase are abandoned, while all projects under construction are assumed to be commissioned).

If constructing a comprehensive project pipeline proves challenging, for instance for residential solar PV for which having access to all consumer projects will be difficult, an alternative approach could be adopted. For technologies already showing signs of acceleration, for instance wind onshore in Germany (see [Figure 37](#)), 2024 auction results and the 2025 volume revisions could be used to extrapolate the most recent growth rates into future projections.

---

<sup>135</sup> The IEA hydrogen production project database can be downloaded [here](#). This Excel file lists all electrolyser projects in Europe, providing various characteristics, including the project status.

## 2.3 Development of low-economy and high-economy scenarios for TYNDP

ACER TYNDP Scenarios Guidelines request that *“the set of mid-term and long-term scenarios shall include the best-estimate central scenario, based on NECPs, and contrasting “low”-economy and “high”-economy variants that serve as stress-tests of the central scenario”*. ACER finds in fact that stress testing network development along the dimension of a more conservative (‘low’) and a more optimistic (‘high’) view on the economy resonates with decision makers.

This section outlines a methodology for developing low- and high-economy scenario variants for TYNDP. Even if this methodology is primarily design for the needs of the TYNDP, the approach is also suitable and could be used for future ERAA processes.

Derived from the central scenario, the scenario variants capture economic sensitivities by varying key parameters that both affect and are affected by a country’s economy, creating a range of outcomes around the central scenario.

### Compliance of the scenario variants with EU energy & climate targets

As stipulated in the TEN-E regulation, all TYNDP scenarios have to be compliant with EU’s energy & climate targets. Therefore, ACER TYNDP Scenarios Guidelines requested the scenario variants to be compliant with the target.

Non-compliant scenario variants would also present some benefits for the energy infrastructure assessment, notably by proposing more differentiated scenarios, and scenarios closer to observed current trends (which might be deemed as more credible by some stakeholders).

The methodology described below is in line with the current regulatory framework and therefore designed to build target compliant scenario variants. Nevertheless, if the regulatory framework were to change, the methodology described below could be adapted to fit the new framework.

### 2.3.1 Suggested approach – Demand

The suggested approach to estimate demand for the variants follows four main steps represented on [Figure 39](#). First, a narrative is set by identifying a set of high-level drivers on which the variant should apply and indicating how this narrative has an impact on these drivers. In the second step, the variation of these high-level drivers is quantified based on the central scenario, the narrative, and, if applicable, historical data. Next, a set of more granular parameters is identified and quantified, based on central scenario values, high-level drivers, historical trend and expert involvement. Finally, these parameter values are used in a model that links them to demand levels and profiles, enabling the estimation of demand for each variant.

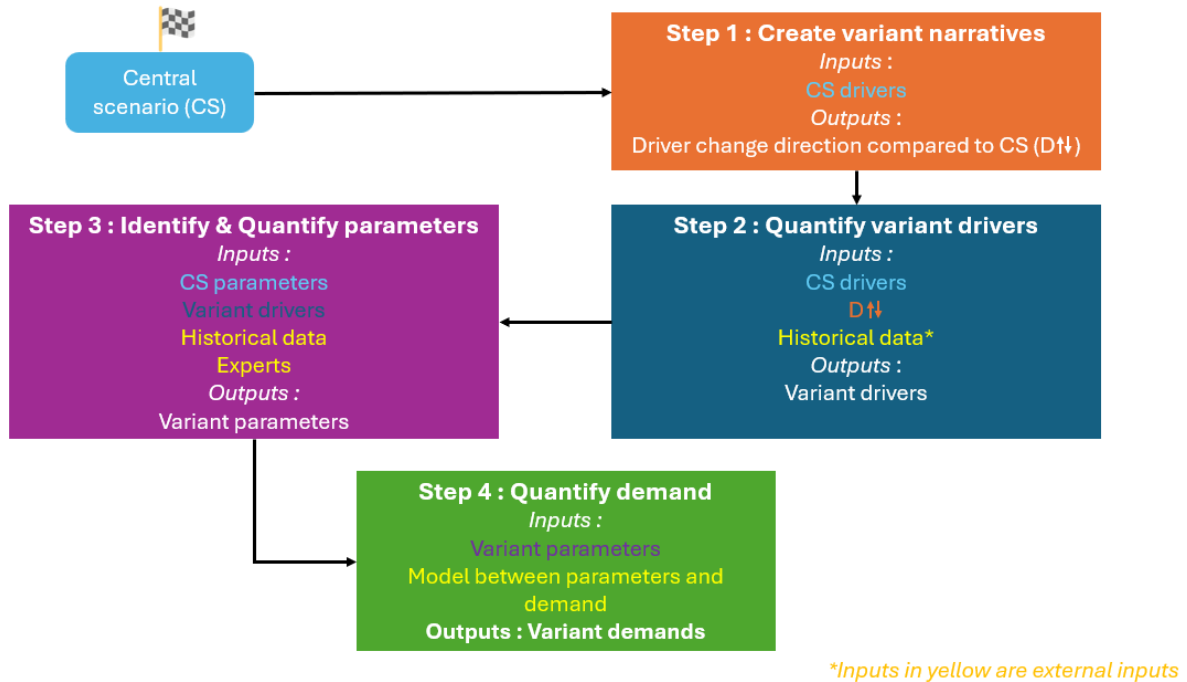


Figure 39 – Process diagram of the suggested approach to estimate demand for TYNDP variants

### Prerequisites for the proposed approach

The approach proposed here requires knowing the values of demand drivers and parameters in the central scenario.

As developed in [Section i.](#) on TYNDP input data and [Section 1.3.2](#) on tools used in TYNDP, the main steps of the central scenario building process are:

- | ENTSO-E and ENTSG collect national data from the national TSOs (e.g. demand and installed capacities of production technologies). TSOs are supposed to provide ENTSO-E and ENTSG the required data relying on the NECPs of their country.
- | ENTSO-E and ENTSG recover these national data and merge them to create scenarios.

Therefore, the demand drivers of the TYNDP central scenario are – in theory – also the demand drivers of the NECPs of the Member States.

The introduction of the Energy Transition Model (ETM) in the demand data collection process from the TYNDP 2026 cycle is a significant effort by ENTSO-E and ENTSG to collect from the TSOs not only the projected demand levels in the NECPs, but also the underlying drivers and parameters. The limitations of the current process as well as recommendations on the ETM are formulated in [section 1.3.2.1 Energy transition model \(ETM\)](#).

No approach that does not require knowing demand drivers and parameters in the central scenario seems satisfactory. Indeed, without anchoring variants to central scenario assumptions, the analysis risks losing consistency between scenarios and variants, and may result in increasing misalignment as uncertainty expands over time. It also strays from common practice encountered in other reports,

where sensitivity analyses are systematically built by adjusting parameters from the central scenario. Consequently:

- | Major efforts to enable efficient and accurate collection of demand drivers underlying the central scenario are key to the successful implementation of scenario variants (as described in in section [1.3.2.1 Energy transition model \(ETM\)](#)).
- | If the parameters reflecting demand drivers in the central scenario are not available, a possible alternative would be to apply a  $\pm x\%$  variation to overall demand. However, given the purpose of the exercise and the critical importance for an accurately updated demand, this approach is not deemed suitable. Therefore, in the rest of this chapter, it is assumed that the parameters reflecting demand drivers in the central scenario are available.

It should be highlighted that the credibility of the central scenario and alignment with the NECP, as well as the robustness of its different high-level drivers will have a crucial impact on the quality of the scenario variants, since the variants will be derived from the central scenario. For instance, if the central scenario includes unreasonably high hydrogen demand without plausible justification, this credibility issue will be carried over to the variants. Therefore, a special attention must be given to the proper calibration of the demand model of the central scenario.

#### **Step 1: Identification of the high-level drivers on which the variants should apply**

The first step of the methodology consists in precisely defining the narrative (or storyline) of the variants, and how this narrative has an impact on the high-level drivers of the central reference scenario.

As highlighted in ADEME's [Transition 2050](#) report (see [Benchmark 5](#)), the narrative of the scenario variant should be methodically defined to ensure that the different high-level drivers vary consistently in the different scenarios.



## Transition 2050 - ADEME

### *Building scenario narratives*

A methodical approach (consisting in the three steps described below) is followed by ADEME to define the narrative for the four scenarios in a fully consistent and integrated way. The quantification of high-level drivers only occurs at the final stage of this complex process.

#### **Clarification of the structuring axes of the story**

Using DEGEST method (Demography, Environment, Governance, Economy, Society, Technologies axes) to analyse other environmental scenarios, ADEME scenarios are positioned within a broader family of scenarios, called “positive synergies”. A clear and consistent narrative is then built based on structural parameters across the following sectors: society, nutrition, passenger mobility, technical, macro-economy, industry.

#### **Exploring the symbolic dimension of the narratives**

Each scenario is given a symbolic identity to guide strategic choices in various sectors. The Multilevel Causal Analysis (ACM) method is used to identify four levels of analysis and conceive consistent futures:

- Litany: Dominant and recurring speeches
- System: Speech on variable and their relations
- World vision: Comments that legitimise and support the futures
- Metaphors: Link futures to symbolics and profoundly anchored myths in our culture

This approach integrates not only scientific and technical facts but elements which speak to intuition, values and experiences, creating more in-depth scenarios.

#### **Expertise and quantified analysis**

Engineering, economic and social expertise are gathered to turn scenarios into quantitative assumptions, using several approaches of integrated calculations. Experts form assumptions to input in sectorial models. An integrator model aggregates results from the different sectorial models. An iterative process is led to check, cross and refine quantifications to achieve consistency between the expertise and the 2050 climate target. Key indicators are chosen amongst outputs for the iteration verification (e.g., Emissions, modal shares of transports, etc.)

#### **Benchmark 5 – Transition 2050's method to build scenario narratives**

For the TYNDP, the ACER TYNDP Scenarios Guidelines specify that variants should be defined for both the mid- and long-term, be contrasted and balanced around the central scenario, and explore variations along dimensions of low- and high- economic growth. However, it is up to the ENTSO-E and ENTSG to translate these guidelines into a more detailed narrative, reflecting variations in key high-level drivers. Moreover, as long as the central scenario is derived from the NECPs, the high-level drivers on which the variants are built should, as much as possible, also be high-level drivers of the NECPs.

For the NECPs, the European Commission recommends Member States<sup>136</sup> to use a set of harmonised values (provided by the European Commission) for the following assumptions:

- | Population
- | GDP growth
- | International fuel prices
- | Carbon price

These high-level drivers could then be used to build the scenario variants. For instance, a low economy variant could be defined as a context of weak economic activity and slow demographic growth, combined with an inadequate policy support for electrification that will lead to a decrease in consumption compared to NT+. In this context, policymakers may struggle to implement large-scale initiatives, further exacerbating the lag in the energy transition. This broad context is quantified in high-level drivers by ENTSO-E and ENTSG:

- | **Population:** Population growth is slower than expected in NT+
- | **GDP growth:** GDP growth is lower than in NT+
- | **Carbon price:** Carbon price is lower than in NT+

## Step 2: Quantification of the selected high-level drivers in the variants

The degree of variation of the high-level drivers in the scenario variants compared to the central scenario should then be determined. The value of these high-level drivers in the central scenario will be key to determine how they should evolve in the variants.

The main difficulty which could be faced at this step would be heterogeneous values of the high-level parameters in the central scenario. As mentioned in the introduction, the European Commission recommends Member States to use a set of harmonised values (provided by the European Commission) when preparing their NECPs, notably on population, GDP growth, international fuel and carbon prices assumptions. However, the harmonised values recommended by the European Commission are not systematically followed by the Member States<sup>137</sup>, which may complexify the determination of the way the high-level parameters should vary in the scenario variant compared to the central scenario<sup>138</sup>.

---

<sup>136</sup> [EC recommended parameters for GHG projections 2025](#). The documents provide recommendations for key parameters projections for the integrated national energy and climate plans. An excel of population and GDP growth values for each UE country is given in addition to prices values in annex of the word document.

However, the harmonised values recommended by the European Commission are not systematically followed by the Member States when preparing their NECPs. The use of the ETM to collect the demand high level drivers and associated parameters will facilitate the comparison of the assumptions followed by the different MSs and support the quantification of how the selected high-level drivers should evolve in the variants (step 2).

<sup>137</sup> For the purposes of this study, a portion of the NECPs was examined. However, an in-depth and exhaustive study of all the NECPs is beyond the scope of this study.

<sup>138</sup> For instance, if heterogenous values are used in the central scenario between the Member States, then the value in the variants could either be:

### Step 3: Identification and quantification of the parameters based on the high-level drivers

**High-level drivers** need to be **connected** to more **granular parameters** in order to effectively estimate demand. However, establishing a systematic mathematical link between drivers and a set of detailed parameters might be too complex in this context, as it presents the following challenges:

- | **Introduces extreme uncertainty:** A straightforward approach to correlating historical high-level drivers' values with parameters would lead to a high risk of mistaking some correlations for actual causal relations. Evaluating variant parameters based on this correlation results in uncertain parameters values. Since these parameters are later used to recalculate demand- with further simplifications and uncertainties in calculations- the accumulated uncertainty would severely undermine confidence in the results.  
As described below Table 9 (page 132), the use of historical trends of parameters could still be used to a certain extent to complement the consultation of national experts (e.g. historical trend of the number of heat-pumps). However, historical trends of the parameters should not be linked to historical trends of high-level drivers (e.g. historical trends on the development of heat-pumps should not be correlated with the evolution of the GDP growth over the recent years).
- | **Complexifies significantly the variant creation process.** To ensure a pertinent estimation of the parameter based on high-level driver value would require a complex model, which would be highly time consuming to develop. In addition, the model could struggle to reach a satisfying ratio between certainty of the estimation and time spent developing the model.
- | **Complexifies appropriation and understanding of stakeholders:** This approach might come off as a black-box approach in which it is difficult to link the values to real trends and current uncertainties identified by stakeholders.

Having a systematic mathematical approach to quantify parameters proves challenging, the study will therefore suggest an alternative method to quantify parameters based on the high-level drivers.

The process of creating variants of a central scenario is common in other reports studied in the benchmark. [Benchmark 6](#), [Benchmark 7](#) and [Benchmark 8](#) provide examples of methodologies followed to create variants and sensitivities.

- 
- A uniform value applied to all Member States (e.g. 30 €/MWh of gas in every Member State)
  - An absolute variation compared to the value of the central scenario applied to all Member States (e.g. + 3€/MWh of gas compared to the value of the central scenario in every Member State)
  - A relative variation compared to the value of the central scenario applied to all Member States (e.g. +20% compared to the value of the central scenario in every Member State)
  - A relative variation compared to the value recommended by the European Commission (e.g. +20% compared to the value recommended by the European Commission in every Member State)



## ADEQFLEX23' - ELIA

### *Sensitivities*

Sensitivities are applied to various demand and supply drivers to assess resource adequacy in different situations, in the form of **asymmetrical low and high sensitivity cases for sector-specific parameters**. Based on these individual sensitivities, four combined scenarios of the previous sensitivities are then created.

#### **Example – Sensitivity analysis in the transport sector**

Sensitivity focuses on:

- The number of electric vehicles
- The level of flexibility they can provide

Sensitivities are introduced by adjusting specific sub-parameters relative to their central scenario values:

- EV penetration (Low and High sensitivities)
  - o Variations of the new sales and electrification rates of:
    - Company passenger cars
    - Private passenger cars
    - Vans
    - Trucks
    - Buses
  - o The corresponding annual electricity demand is adjusted accordingly.
- EV flexibility (No, Low and High sensitivities)
  - o Variations are applied to:
    - The share of vehicles following standard charging profiles
    - The development of Vehicle-To-Grid (V2G)

While tables detailing parameter values for each sensitivity are provided, the methodology for determining these values and variation compared to the central scenario values is not explicitly stated. It is mentioned, for instance, that a former study from LCP delta played a significant role in shaping flexibility assumptions, notably for the sensitivity analyses.

#### **Benchmark 6 – Methodologies to create sensitivities in ADEQFLEX23'**



## Futurs énergétiques 2050 – RTE

### *Creating variants*

The report has a reference demand trajectory that is meant as a NECP representation

Two alternative scenarios and four variants of this demand are created, with the goal to represent a cone of values around the reference trajectory. The scenarios represent different narrative, while variants are sensitivities on the reference demand trajectory. Four variants are created instead of two (which would have been sufficient to have high and low demand variants) in order to have a refined analysis of each parameter's impact on demand. The following parameters are varied; increased or decreased from reference trajectory values:

- **Sobriety (Scenario 1):**
  - Sources of sobriety in each sector are identified and varied. Sources of sobriety are identified as parameters that can be varied to reflect consumer's more sober behaviours (see example below)
- **Deep re-industrialisation**
  - GDP - Increased
  - Industry share in GDP - Increased
- **Electrification +/-:**
  - Transfer to electric heating in residential/tertiary/industry sector – Increased/Decreased
  - Number of EVs – Increased/Decreased
  - Share of electrified trucks – Increased/Decreased
- **Least energy efficiency:**
  - Renovations in residential/tertiary - Increased
  - Heat pumps in housing - Increased
  - Vehicle consumptions - Decreased
- **Hydrogen +:**
  - Electricity consumption for hydrogen production – Increased

#### **Breakdown of parameters:**

For the Scenario 1, sobriety is broken down in its sources, and quantified:

- **Propensity:** natural tendency of individuals to accept space sharing is translated into a quantitative assumption on the size of household and an increase in the share of mutualised housing
- **Temperature:** lowering heating setpoint temperature and a reduction in hot water use

There is no further mention of how the parameters' variations are quantified. Estimations of nuclear installed capacities are a product of the consultation system, justified using quantified arguments on the possible boundaries of EPR rhythm of development for example.



## Canada Energy Futures - CER

### *Creating “What if” scenarios*

Canada Energy Futures presents three main scenarios:

- **“Canada net-zero”** where Canada achieves net zero by 2050
- **“Global net-zero”** where Canada achieves net zero by 2050 and the rest of the world reduces emissions enough to limit global warming to 1.5°C
- **“Current measures”** which represents a failure to achieve net zero

On the top of the three scenarios, the report explores **five “What if” scenarios**, each assessing the impact of uncertainties on the pathway to net zero. These “what if” scenarios are presented as questions, based on the variation of factors chosen for the potential magnitude of their **impact** and the level of **uncertainty** surrounding them, often the pace and scale of technology deployment.

All the sensitivities are built with the constraint to **maintain the achievement of climate objectives**, with emissions constraints being embedded in the model. Varying assumptions therefore influences energy mixes and economic outcomes, potentially shifting the pathway toward a more or less economically optimal solution. “What if” scenarios are compared against the “Global net-zero” scenario. The five Canadian “What if” scenarios are:

- What if technologies to enable wide scale adoption of **hydrogen** are more or less costly
- What if **small modular reactors (SMR)** technology matures less quickly and is more costly
- What if **direct air capture** technology matures more quickly and is less costly
- What if **carbon capture utilisation and storage** technology does not mature as quickly and is more costly
- What if **EV charging patterns** results in higher peaks of electricity demand. For instance, in this scenario, the energy mix shifts favours wind over solar to manage peak load, affecting installed capacities and system costs, while still achieving climate goals.

#### Benchmark 8 – Definition of “What if” scenario in Canada Energy Futures

In a similar manner to the methods /present in other reports, the most reliable approach to quantify the parameters based on the high-level drivers seems to be to define a set of smaller-level parameters and quantify each of them. While various parameters influence the modelling outputs to some extent, only a limited selection of parameters should be subject to variations to keep the process tractable and manageable. Ideally, the chosen parameters will be those that exhibit high uncertainty and/or have a strong impact on results and align with the scenarios narratives. Consumption is mainly influence by three aspects:

- **Activity:** A sector's activity reflects the scale or intensity of operations (or the evolution of the energy end-used). Quite simply, more activity leads to more energy use, making this a primary driver of demand.
- **Equipment stock evolution:** this parameter captures the evolution of the technology mix, especially the shift from fossil-based to electric or hydrogen technologies (e.g. in the transport, industry or heating). This transition alters significantly the volume of energy consumptions of the different carriers, and the overall demand levels.
- **Efficiency:** Improvements in technological performance can moderate or amplify the impact of changes in activity and electrification in a significant way.

To strike a balance between simplicity and relevance, each sector's key parameters can be, as much as possible, grouped into these three categories: activity, equipment stock evolution, and efficiency — with at least one parameter represented in each category. In order to have concrete parameters, the parameter in each category can choose to focus on a specific technology, that represents the major influence on this category. For example, in the heating sector, demand evolution is primarily driven by the adoption of heat-pumps and electric heating. As such, equipment stock evolution can be focussed on these two key technologies. The table below suggests some key parameters, split by sector, which would serve as a basis to estimate demand.

<b>General</b>		GDP
		Population
<b>Demand</b>	<b>Household &amp; buildings</b>	Activity (depending on the heated/cooled surface)
		Number of heat pumps
		Number of electrical appliances
		Efficiency: number of insulated homes/number of renovations
	<b>Transport</b>	Activity (reflects transport intensity)
		Number of EVs / hydrogen vehicles
		Share of flexible charging in EVs
		Share of electrical rail freight
		Vehicles' efficiency
	<b>Industry</b>	Electrification/switch to hydrogen of machinery
		Activity (reflects production levels)
		Machinery efficiencies
	<b>Agriculture</b>	Electrification of machinery
		Activity (reflects production levels)
		Machinery efficiencies

**Table 9 – Proposal of a selection of parameters to create variants**

Activity parameters could partially be explained by GDP and/or population evolution (but partially only). But equipment stock evolution would be harder to link to high-level drivers such as GDP, because the relation is more indirect. Therefore, consultation of national stakeholders and experts seems to be necessary to determine the parameters' variations in the variants compared to the central scenario. Expert involvement could be complemented with other approaches, such as:

- | **Historical trends:** Support the proposed range with data-driven justifications based on past trends (e.g., historical EV sales, policy delays, etc...)
- | **Parameter breakdown:** Decompose the parameter into other parameters (either smaller-level or intermediate), and base the variation on these other parameter's variations, using historical trends. This approach can facilitate estimations if information is more accessible on other parameters, or by allowing for targeted expert input. See for an example of parameter breakdown.

It is important to note that ACER TYNDP Scenarios Guidelines require the variants to be “**contrasted**” and “**balanced**”. Having contrasted variants means that parameter variations must represent meaningful differences from the central scenario and fit a consistent narrative. As mentioned above, parameters can be technology-specific, so applying the same type of variation uniformly across all parameters may lead to inconsistencies. While some parameters can be reasonably varied by a  $\pm x\%$  range, others may require discrete assumptions instead. For example, in a low-economy variant, it might be more appropriate to assume zero hydrogen adoption in the residential sector rather than simply reducing demand by a certain percentage compared to the central scenario. This discrete approach can better capture significant shifts in technology adoption or usage.

Having balanced variants means they should remain plausible within the narrative framework. While having contrasted variants is important, they should represent realistic differences rather than maximizing contrast for its own sake.

Balanced scenario variants does not mean that the variants have to be symmetrical. For example, discrete approach (e.g. 0 hydrogen in the buildings in the low economy scenario variant) can totally be followed. Low and high economy variants may show similarly significant narrative wise parameter changes but asymmetrical numerical changes of the same parameter.

#### Step 4: Estimating demand based on parameter values

The last step of the proposed approach would be to estimate annual demand based on the values of the demand parameters described above. For this last step, the use of the ETM would simplify and streamline the process (because it would avoid the development of a new dedicated model). The quantified variant parameter values (see [Step 3](#)) are entered using the ETM sliders, and their combination determines the resulting variant demand levels.

**NB:** it should be highlighted that the present proposal is only to use the ETM only for the translation of these smaller-level parameters, influencing consumption (on activity, equipment stocks and efficiencies) into annual demand volumes, and not for the translation of high-level drivers into demand parameters (as explained in step 3 above). The ETM is used with a bottom-up approach to estimate demand once variant parameter values have been determined rather than using it to determine parameter values.

Demand hourly profiles also need to be adapted in the variants, with the same approach as for ERAA additional scenario (see section [2.2.2.2 Methodology to project demand](#)).

### Illustrative numerical example

An illustrative numerical example is given on [Figure 40](#). The example refers to the percentage of hydrogen heating in residential buildings. The numbers are illustrative, and expert input is needed at several steps to ensure the consistency of input parameter values. Those values are then used in the ETM to estimate demand. Note that in this example, variations between the low and high economy variants are asymmetrical but the narrative are built to represent balanced variants.

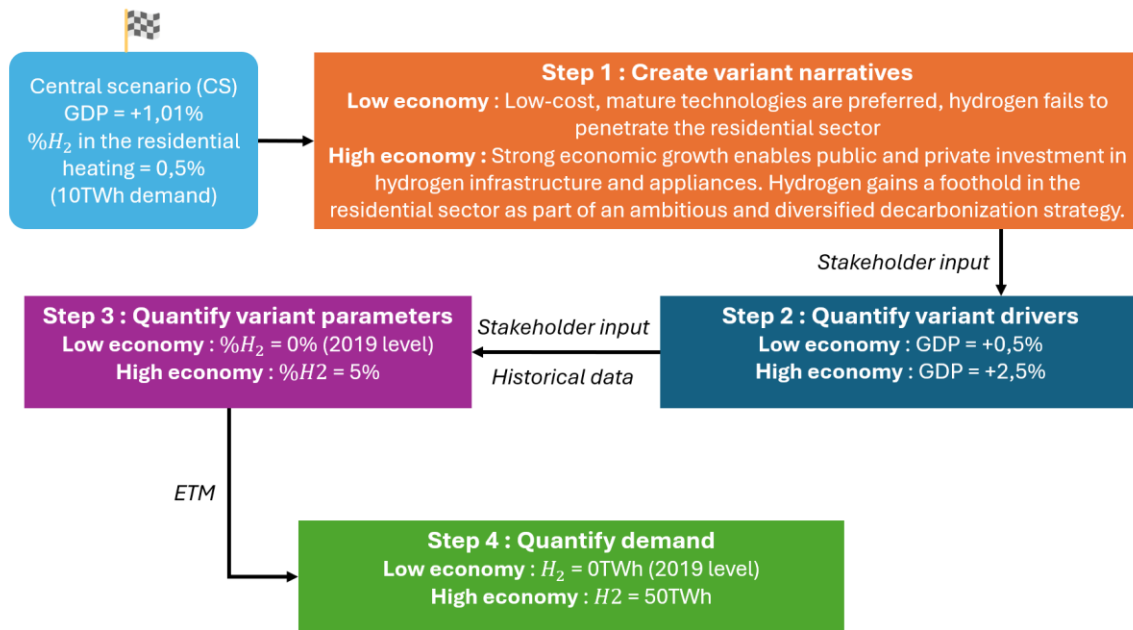


Figure 40 – Numerical example of the suggested approach for low and high economy TYNDP variants

## 2.3.2 Suggested approach – Supply

### Requirements that the methodology must meet

Similarly to changes on the demand, assumptions on the supply should also differ between the central scenario and the variants. The deviations of the variants from the central scenario on supply should reflect two aspects:

1. The differences in energy demand between the central scenario and the variants should have an impact on the amount of new generation capacity and hydrogen imports. Indeed, demand projections is one of the drivers of the development of generation capacity. For instance, a scenario with higher demand would most likely translate into higher generation installed capacity.
2. In order to keep scenarios with a consistent narrative (as described in [Benchmark 5](#) above), high-level drivers which affect the supply should also evolve in a consistent way with the high-level drivers which affect the demand. For instance, a low economy variant is limiting capital allocation for renewable projects and should, as a result, not only reduce the energy demand but also the deployment of renewable compared to the reference scenario.

### Suggested approach

The philosophy of the methodology proposed here is to assume that the variants should have the same levels of achievement of the European energy and climate objectives in terms of renewable shares and GHG emissions<sup>139</sup>, and meet the same reliability standards.

Based on this assumption, an iterative expansion/decommissioning process can be followed to adjust installed capacity mix. This approach is partially inspired by the approach of the “What if” scenario in Canada Energy Futures (see [Benchmark 8](#)).

The main steps of the proposed approach are represented on the graph on the right.



### Step 1 – Adaptation of the hydrogen supply mix

The general philosophy of the adaptation of the hydrogen supply mix consists in assuming that a higher hydrogen demand would result in higher imports and higher electrolyser installed capacities, and conversely in case of lower hydrogen demand.

In concrete terms:

- | The hydrogen production from fossil fuels (SMR, ATR) or as a byproduct is supposed to remain at the same level between the central scenario and the variants<sup>140</sup>. As a result, the entire variation in the hydrogen demand is supposed to be entirely compensated by imports and

<sup>139</sup> In this approach, the focus is set on the share of renewables and GHG emission reduction objectives. Indeed, forcing the scenario variants to have the same total final energy consumption as the central scenario would contradict the philosophy of the high and low economy scenario variants.

Even a simplified approach, such as reducing proportionally fossil fuel demand until the energy efficiency targets are reached (similarly to the gap filling methodology implemented in the TYNDP 2024), seems unsatisfactory because (1) it is disconnected from the reality and (2) it would artificially reduce GHG emissions and increase the share of renewables, and therefore reduce the need to adapt the supply side of the scenario variants.

<sup>140</sup> In some specific Member States where NECPs expect an increase of SMR/ATR capacities compared to the current levels, SMR/ATR capacities could also be manually adjusted in the scenario variants compared to the central scenario. Such case-by-case manual adjustments would happen during the validation stage with national stakeholders (see Step 4 below).

electrolysis targeted production<sup>141</sup>. This modelling choice is justified by the fact that hydrogen generation from fossil fuels are mostly existing assets, whose capacity is little impacted by economic conditions or the evolution of hydrogen demand.

*For example, if a given country has a hydrogen consumption of 6 TWh/year in the central scenario (4 TWh/year of which produced from electrolysis, 1 TWh/year imported from extra-EU countries and 1 TWh/year of which produced from methane), and that the hydrogen demand is reduced to 5 TWh/year in the low-economy variant, then 1 TWh-demand-reduction will be allocated proportionally to imports and electrolysis. Therefore, the imports will be reduced to 0.75 TWh (-25% compared to the reference scenario) and the targeted production from electrolyzers will be reduced to 3.25 TWh (-25% compared to the reference scenario).*

- | The electrolyzers' installed capacity is adjusted proportionally to the electrolysis targeted production, in order to keep the average capacity factor of electrolyzers (and consequently their flexibility) at the same level as in the reference scenario. This modelling choice will enable to limit side effects due to changes in the level of flexibility of electrolyzers in the assessment of the scenario variants.

*In the example above, electrolyzers installed capacity would also be reduced by 25% compared to the central scenario.*

## Step 2 – Constrained capacity expansion on wind and solar installed capacities

The general philosophy of the adaptation is to ensure that the scenario variants meet the same share of renewable as in the central scenario. To that end, a joint optimisation of the hourly dispatch and the wind and solar capacity expansion could be set up, but with strict constraints on how wind and solar capacity are allowed to deviate from the central scenario.

While the proposed methodology may at first glance appear similar to the approach used to build the deviation scenarios (Distributed Energy and Global Ambition) in the TYNDP 2024 cycle (which was criticized for its limited realism and excessive deviation from the National Trends scenario), because of the use of capacity expansion and dispatch optimisation models, the way the model will behave and optimise the installed capacities will differ significantly. This is primarily due to the two additional constraints that limit how wind and solar capacities can deviate from the central scenario.

### *Constraint 1 – The share of renewable in the variants must stay at the same level as in the central scenario*

The renewable target is set on the total energy consumption (and not on each energy carrier). As a result, the first step is to compute, for each country, the **share of renewable energy the hydrogen and**

---

<sup>141</sup> The wording 'targeted production from electrolyzers' is used here because the production from electrolyzers is a result and not an input to the model (because the dispatch of hydrogen production from the different technologies is optimised). The translation of 'targeted production from electrolyzers' into input parameters of the model is explained below.

**electricity interconnected systems must meet** in the variants in order to keep the share on renewable energy in the total energy consumption at the same level as in the central scenario.

The target share of renewable will be a **hard constraint**, in the sense that the optimisation will not be allowed to go above or below this target. In other words, **the variants will have to meet the exact same share of renewables in the variants as the central scenario**. The capacity expansion will not be allowed to install more renewables than necessary to meet the renewable target, **even if this reduces the system cost**.

*Constraint 2 – The direction of the variation of installed capacities compared to the central scenario must be the same for wind and solar and the same for all countries.*

These constraints forbids for instance to increase solar installed capacity and reduce wind installed capacity at the same time, or to increase RES capacities in a country A and reduce them in a country B at the same time.

These two constraints are **fundamental** in the proposed approach, as they limit the divergence of the variants from the central scenario and ensure that any differences arise solely from demand assumptions- not from theoretical re-optimisation or biases linked to difference in model types (dispatch optimisation vs. capacity expansion)

This pivotal point is the key difference between the approach proposed here and the least-cost optimisation methodology previously used for Distributed Energy (DE) and Global Ambition (GA) scenarios, developed in the TYNDP until 2024 cycle. Indeed, while the main driver in the optimisation of DE and GA scenario was to minimise the system cost (which led to significant deviation compared to NT/NT+ scenario), the main driver in the methodology proposed here will be to reach (and not exceed) a certain share of renewables.

These constraints are required because the central scenario (NT+) scenario is formed by aggregating inputs from various TSOs and does not rely on capacity expansion for its supply assumptions. If the assumptions of the central scenario were to be integrated into a capacity expansion model, the resulting installed capacities would significantly differ from the current central scenario results, as any aggregation of installed capacities is unlikely to coincide with a theoretical economic optimum based on a system cost minimization under a demand/supply equilibrium constraint. **As such, introducing pure capacity expansion into the variant construction process (without these two hard constraints on how installed capacities are allowed to deviate compared to the central scenario) would lead to substantial divergence from the central scenario, which would not be the consequence of differences of narratives or high-level drivers between the scenarios, but rather a consequence of differences in modelling approaches.**

A third constraint on reaching the exact same GHG reduction as in the central scenario could potentially be added to the model (depending on the requirements of the variants). In this case, this third constraint of GHG emission would have to be implemented in a similar way as the first constraint.

### Step 3 – Security of supply loop to adapt the peak capacity

Given TYNDP main objective of assessing infrastructure needs and projects, the scenario variants should have the same reliability standards as the central scenario, for every country. To that end, a similar workflow as the “Security of supply” loop developed by ENTSO-E as a preliminary step of the CBAs<sup>142</sup> would be run. In brief:

- | A dispatch model is run in order to calculate the number of Loss of Load (LOL) hours in the central scenario.
- | Until the same number of Loss of Load hours is met, additional capacities are installed, or existing capacities are decommissioned.

This adjustment can result in additional or reduced capacities compared to the central scenario (depending on the evolution of the demand and of the installed capacities of other technologies).

Similarly to wind and solar capacity adjustment, the capacity variations compared to the central scenario will only be allowed in one single direction. In other words, the model will not be allowed to decommission some peak technologies and commission others, even if this reduces the system cost.

The parameters of this adjustment (technologies allowed to increase or decrease, technology commissioning and decommissioning priority order, constraints on the capacities to be (de)commissioned) will have to be discussed with the involved stakeholders.

### Step 4 – Validation of the results with national stakeholders and potential iterations

The results of the optimisation would then have to be **validated by national stakeholders**. This step is necessary to ensure that the result of this capacity adjustment is plausible and consistent with the country's energy context (given that the capacity adjustment is the result of mathematical optimisation at this stage).

The national stakeholders should in particular provide insights on two points:

- | Should other generation technologies than the ones already addressed in the proposed methodology (namely hydrogen imports, electrolysers, wind, solar and peaker capacities) be adjusted in the scenario variants compared to the central scenario? In some specific cases where the narrative of the variants would have a significant impact on the evolution of other technologies (e.g. CCS technologies or nuclear), national stakeholders could be allowed to request for ad hoc manual adjustments of the installed capacities of other technologies than the ones already addressed in the proposed methodology.

**NB:** the way other technologies (in particular nuclear) evolve strongly depends on political decisions and can therefore not be optimised. This justifies why expert involvement is required to determine how these technologies should evolve in the variants compared to the central scenario.

---

<sup>142</sup> See section [3.1](#) of the present report for further details.

- | Is the portfolio of technologies proposed by the optimisation and modelling process described above relevant and consistent with real situation in the country concerned?  
For instance, depending on the cost and load factors assumptions of the different technologies, the optimisation could decide to deviate from the central scenario in a high-economy scenario, only by adding wind capacity (instead of a mix of wind and solar), or symmetrically, in a low-economy scenario, only to remove solar capacity (instead of a mix of wind and solar). Such results may be unrealistic given the real situation of a country (e.g. wind capacity already reaching the maximum installed capacity in the central scenario). This is why the intervention of national stakeholders at this stage seems required to ensure that the scenario variants are robust.

The national stakeholders involved in this step could be TSOs, NRAs or ministries. Governance rules for these ad hoc adjustments need to be determined, in order to guarantee the **objectivity** of the ad hoc adjustments (e.g. by requiring TSOs to obtain authorisation from their NRAs to make these adjustments), as well as to guarantee **homogeneity** between the various countries (e.g. by establishing a committee for validating adjustments on a case-by-case basis, which could involve European-wide institutions such as ACER, ENTSO-E and ENTSOG, the Commission or the SRG).

Interventions of national stakeholders will then be translated into **additional constraints** to the model (e.g. maximum wind capacity which can be added in the high-economy scenario compared to the central scenario), which would require to relaunch the whole modelling and optimisation process integrating these constraints.

### Illustrative numerical example

An illustrative numerical example is provided in the figure below. The example reflects a situation where the final energy demand is lower in the scenario variant than in the Central Scenario, requiring therefore to adjust downwards the renewables installed capacities in order to keep the same share of renewables in the scenario variant as in the central scenario, and where the hydrogen demand is lower in the scenario variant than in the Central Scenario, requiring therefore to adjust downwards the electrolysers installed capacities and extra-EU hydrogen imports.

Numbers are illustrative, as the ETM and power system optimisation are required at several steps of the proposed methodology.

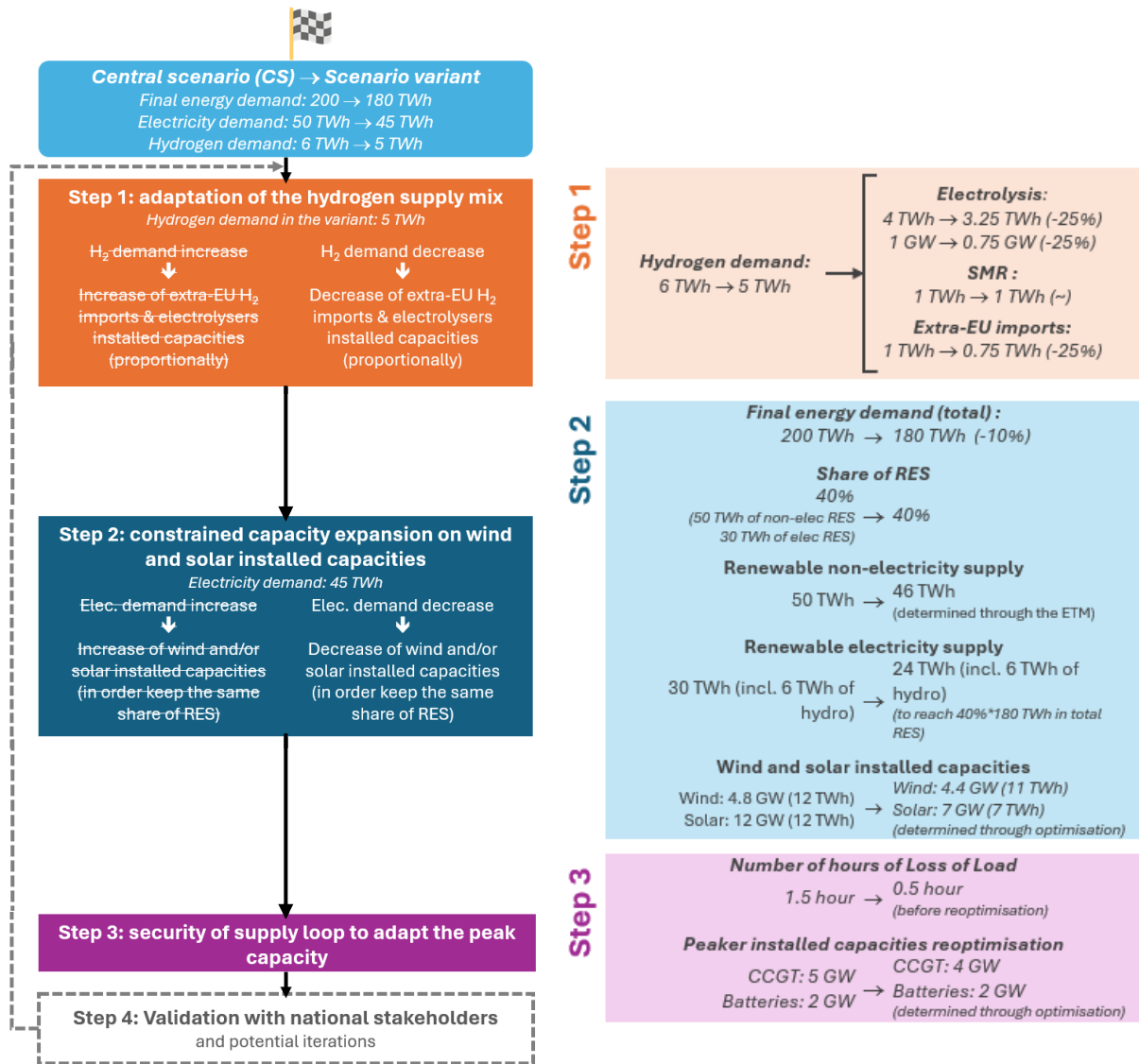


Figure 42 – Numerical example of the suggested approach for low and high economy TYNDP variants on the supply side

### 2.3.3 Comparison of the proposed approach to ENTSO-E and ENTSGO' proposed approach for the TYNDP 2026 scenario variants

On 1 July 2025, ENTSO-E and ENTSGO launched a public consultation on the TYNDP 2026 Scenarios Economic Variants Development Methodology<sup>143</sup> running until the 29 July. ENTSO-E and ENTSGO have held a public workshop on 4 July 2025 to present their proposed approach.

<sup>143</sup> [Link](#)

The draft methodology for TYNDP economy variants proposed by ENTSO-E and ENTSOG presents similarities with the approach proposed by Artelys above<sup>144</sup>.

- | On the demand side, the proposed approaches are similar:
  - Both approaches propose to rely on the ETM (even though some reservations and recommendations regarding the use of ETM are outlined by Artelys – see section [1.3.2.1 Energy transition model \(ETM\)](#)).
  - Both approaches identify the same three categories of parameters (activity, equipment stock evolution and efficiency). However, ENTSO-E and ENTSOG approach excludes modifying the efficiency parameters, assuming that the efficiency parameter is already covered by the technology choice (e.g. heat-pump adoption), while Artelys does not exclude this a priori.
  - In both approaches, the values of the parameters are mainly determined based on expert judgement. In particular, none of the two approaches propose mathematical models/equations to link the value of the parameters (e.g. number of heat-pumps) to the value of the high-level drivers (e.g. GDP growth or commodity prices).

The main differences between the two approaches on the demand side are that:

- In the approach proposed by ENTSO-E and ENTSOG, parameters variations are always symmetrical between high and low economy variant, while Artelys considers asymmetrical variation, which can result in a complete exclusion of some technologies in the low economy variant (e.g. hydrogen development totally excluded in the residential sector in the low economy scenario variant).
  - Artelys recommends complementing expert involvement with historical trend analysis on the evolution of the parameters and/or by breaking down parameters into more granular components, while this is not explicitly mentioned in the approach proposed by ENTSO-E and ENTSOG.
- | On the supply side, the proposed approaches are different:
    - Artelys' approach consists in an iterative expansion/decommissioning process in order to adjust the installed capacity mix to meet the levels of demand (arguing that the scenario variants should have the same levels of achievement of the European energy and climate objectives in terms of renewable shares and GHG emissions, and meet the same reliability standards as the central scenario, and therefore that a scenario variant with higher energy demand should have higher installed capacities and conversely).

---

<sup>144</sup> Even though the present report is published in August 2025, it should be highlighted that Artelys built its methodology proposal independently from ENTSO-E and ENTSOG's methodology development process. In fact, Artelys' scenario variants development process lasted until 16<sup>th</sup> June 2025 (date at which Artelys submitted its proposal to ACER) – ahead of the presentation by ENTSO-E and ENTSOG of their proposed approach. The present comparison section was added in a later stage of the project (without influencing Artelys' proposal for the variants).

- In contrast, the approach proposed by ENTSO-E and ENTSOG does not consider possible capacity expansion (unless if “technically necessary”<sup>145</sup>). The capacity mix remains the same in the scenario variants as in the central scenario. The scenario variants are differentiated on the supply side on CO2 and commodity prices.

Complexifying the scenario variant methodology proposed by ENTSO-E and ENTSOG on the supply side as of the TYNDP 2026 cycle might not be appropriate, as the scenario building process is already well under way. The proposals of this report could therefore be considered for the upcoming TYNDP cycles (i.e., TYNDP 2028 and subsequent editions).

---

<sup>145</sup> For more details, see ENTSO-E and ENTSOG’s public workshop of 4 July 2025 on TYNDP 2026 Economic Variants Development Methodology – [Link](#) (slide 12).

### 3 Task 3 - Comparison and recommendations for convergence between the scenario definition in the TYNDP and ERAA

TYNDP and ERAA serve distinct regulatory objectives and rely on different methodological choices, their scenario-building processes are increasingly interlinked and often rely on overlapping data sources and assumptions. As such, greater consistency and alignment between the two exercises could enhance the overall coherence of European energy system planning.

This section identifies the key structural and modelling differences between TYNDP and ERAA scenarios, including purpose, governance, time horizon, granularity, and network representation, and presents recommendations for improving convergence where appropriate. A high-level description of these differences is summarised in the table below.

**Table 10 – General differences between ERAA and TYNDP contexts**

Scenarios	ERAA	TYNDP
<b>Objective of the scenario</b>	Resource adequacy	Long-term infrastructure planning
<b>Scenarios structure</b>	The ERAA 2024 presents one central scenario (with harmonized CONE assumptions and based on NECPs) as its main framework, but it also considers sensitivity analyses comparing the Central Reference Scenario with alternative CONE assumptions, which represent the current trends in the future.	The TYNDP 2026 presents one central scenario (based on NECPs) and two scenario variants (low- and high-economy variants).
<b>Entities in charge of developing the scenario</b>	ENTSO-E	ENTSO-E and ENTSO-G
<b>Frequency of publication</b>	Annual	Every two years
<b>Sectoral coverage</b>	Mainly electricity	Multi-energy exercise: electricity, gas, hydrogen, biofuels, etc.
<b>Time horizons</b>	Medium-term: ten years ahead	Long-term. In TYNDP 2024, NT+ scenario covered 2030 and 2040, but other scenarios also covered 2050.
<b>Network representation</b>	Electricity reference grid (NTCs and FB domains)	- Hydrogen reference grid

		- Electricity reference grid (only NTCs)
<b>Granularity of the generation fleet</b>	Unit level	Technology fleet level

Despite these differences, both scenarios share many common points, notably:

- | Both scenario building process are based on the same type of modelling (bottom-up hourly dispatch optimisation models).
- | As a consequence of the first point, both scenarios require many input data in common.
- | Both scenarios should be based on national plans/NECPs.

This section is dedicated to addressing the following objectives:

- | Identifying the common elements and differences in the development of the central scenario for both ERAA and TYNDP.
- | Highlighting areas where further alignment is possible, and where discrepancies are justified based on the specific objectives of each exercise.
- | Providing recommendations informed by the analysis, aimed at improving coordination, consistency, and process efficiency between the two exercises.

The following sections investigate into the comparison of scenario definition processes, stakeholder engagement, and modelling approaches in more detail.

### 3.1 Supply

The electricity generation components are generally considered among the most aligned aspects between TYNDP and ERAA, and this despite the differences in terms of modelling granularity of the generation fleets between the two scenarios:

- | In ERAA, simulations are performed at the unit level, using a unit commitment approach that includes binary variables for start-up and shutdown decisions.
- | In TYNDP, generation capacities are typically aggregated by technology fleets within each bidding zone, leading to less granularity in modelling individual asset behaviour.

This strong alignment is made possible in particular by Pan-European Market Modelling Database (PEMMDB) tool, which is used by ENTSO-E to collect the relevant input parameters for both exercises. The input data are collected from the national electricity TSOs at the unit level (which is required for ERAA modelling) and are then aggregated by ENTSO-E to meet TYNDP’s granularity requirements.

It is also important to highlight that ENTSO-E has established, within the System Development department a Data Team, which is responsible for coordinating the data collection processes across all scenarios developed by ENTSO-E (not only for TYNDP and ERAA, but also for other exercises such as the Seasonal Outlooks).

In parallel, each TSO designates market data correspondents, who are tasked with preparing and submitting the data required for these exercises. This structured approach helps ensure continuity and internal coordination within each organisation. However, despite this framework, further standardisation and harmonisation of data sourcing practices, particularly in cases where NECPs are incomplete, remain a key area for improvement. In addition, greater traceability is needed to clarify which data has been provided by national TSOs, ensuring accountability for the assumptions used. This is especially important, as for the stakeholders it is often unclear whether the data originates from national sources or ENTSO-E and ENTSG directly, as ENTSO-E and ENTSG gather them, consult and use in their exercises.

### **Timeline differences between ERAA and TYNDP can generate input data differences**

The fact that both ERAA and TYNDP use the PEMMDB platform for data collection does not necessarily mean that the assumptions used in both scenarios are the same. First, differences in the timing of the two processes can occasionally introduce discrepancies in the input values submitted by TSOs, creating a barrier to full alignment. For instance, over the past cycles, data collection periods from the TSOs systematically started or ended at different dates.

In the on-going editions of both exercises (ERAA 2025 and TYNDP 2026 cycles), the data collection has, for the first time, started at the same time, which enabled ENTSO-E to carry out one single data collection from the national TSOs for both exercises. However, due to the different durations and internal timelines of ERAA and TYNDP, the data collection processes may not conclude simultaneously. In particular, ERAA process will require to define an earlier cut-off date (date after which modification of input data cannot be taken into account in the scenarios) than TYNDP. Therefore, TYNDP 2026 may include input data updates which may not be reflected in ERAA 2025.

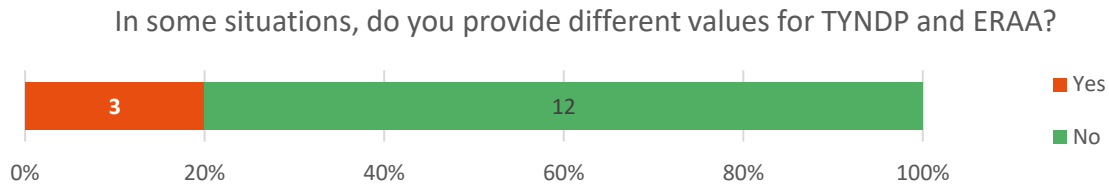
### **Recommendation 16 – Alignment of ERAA and TYNDP data collection timelines**

Further alignment of PEMMDB data submission timelines should be explored to minimise preventable discrepancies between ERAA and TYNDP:

- | Best solution: Making ERAA bi-annual instead of annual and aligning both the timeline of the ERAA and TYNDP. This would be the best option to have a full alignment of the two exercises.
- | First alternative: Considering ERAA annual (as it is now), aligning the beginning and (if possible) the end of the data collection process of the ERAA and TYNDP. This would improve the alignment in terms of assumptions.
- | Fallback solution: If the above recommendations cannot be implemented, the publication of version tracking (with release IDs corresponding to the different milestones of the scenarios development process, and release notes for each version specifying the changes compared with previous versions) would allow greater transparency.

### In a few cases, some TSOs intentionally provide different values between ERAA and TYNDP for some input parameters

Another reason which explains deviations between ERAA and TYNDP input data is the fact some TSOs intentionally provide different values. However, it should be noted that this remains a relatively rarely used practice, as displayed on the figure below.



**Figure 43 – Different values of the same parameter for TYNDP and ERAA. Source: Artelys' survey to electricity and gas TSOs**

The TSOs who follow this practice justify it by arguing that there is a need to adapt some inputs to the specific objectives of each exercise. For example, some TSOs have reported a more conservative approach on projections of new thermal capacity in ERAA than in TYNDP (in particular in the situation where the development of new thermal capacities may depend on the existence of capacity remuneration mechanisms which are not legally approved yet).

Without prejudging specific situations in certain Member States that may lead some TSOs to providing different inputs between the TYNDP and ERAA exercises, the general rule should be to provide the same data for both scenarios, insofar as both scenarios must be based on NECPs (see [footnote 21](#) on page 23), and TYNDP and ERAA modelling workflows are already taking into account the specific objectives of each exercise.

For example, potential capacity markets should in principle only be considered by the TSOs, both for ERAA and TYNDP, if they are assumed in the NECP or in any other more up-to-date national energy policy plan. The different objective of the scenarios (and the need for a more conservative approach on peak capacities needed in ERAA than TYNDP) should not be addressed at the stage when the TSOs provide national data, as it is accounted for at a later stage of the workflow:

- | In ERAA, the Economic Viability Assessment (EVA) enables to remove from the model any unit for which energy-only-market revenues are insufficient to deliver economic viability. Units which benefit from a capacity remuneration mechanism (CRM) are excluded from the EVA for the duration of their contracts<sup>146</sup>. However, CRMs that are not yet in place are not sufficient to exclude units from the EVA.

Therefore, if a Member State considers a CRM in its NECP, then the TSO should provide peak capacity projections assuming that this capacity market will be in place, and the peak capacity projections provided by the TSO will be reduced through the modelling of the EVA step.

<sup>146</sup> ERAA 2024 – Annex 2: Methodology report – [Link](#) (footnote 12 on page 39).

- | In TYNDP, the Security of Supply loop (described in ENTSO-E Implementation Guidelines for TYNDP 2024<sup>147</sup>) enables to add or remove capacity to reach scenarios that meet adequacy criteria, and that are thereby fit-for-purpose for CBAs.

Therefore, if a CRM is under discussion in a Member State because adequacy issues are identified in the long-term, but not yet included in the NECP or enshrined in law, then the TSO should provide peak capacity projections assuming that this capacity market will not be in place, and the peak capacity projections provided by the TSO will then be increased through the modelling of the security of supply loop, in order to obtain adequate scenarios for the CBAs of infrastructure projects.

### **Recommendation 17 – Voluntary deviations between ERAA and TYNDP input data provided by the TSOs**

In principle, voluntary deviations between ERAA and TYNDP scenario inputs provided by the national TSOs should not happen. If specific situations in certain Member States require some TSOs to provide different inputs into the ERAA and TYNDP exercises, then the deviations should be:

- | Made transparent and justified (e.g. in a dedicated document, which could be similar as the one proposed in [Recommendation 3](#))
- | Scrutinised and validated, at least by the NRA of the Member State (as described in [Recommendation 6](#)).

### **The Economic Viability Assessment (which adjusts the capacity mix) is only carried out for ERAA**

After the data collection phase is completed, further divergences in capacity mix can occur. In ERAA, the capacity mix is dynamically modified through the Economic Viability Assessment (EVA). This module evaluates the economic feasibility of generation units and may recommend the decommissioning of unviable units, or the commissioning of new ones based on cost-effectiveness. In contrast, for the TYNDP NT+ scenario, the capacity mix remains fixed throughout the entire scenario-building process, based on initial assumptions provided during data collection.

This methodological divergence mirrors the differences in the mandates of ERAA and TYNDP: ERAA's dynamic EVA allows resource adequacy assessments to shadow near-term market realities (e.g. unviable unit retirements); and TYNDP's static capacity mix is consistent with the scenario's role as a policy-compliant infrastructure planner under TEN-E Regulation. Although contrasting, these strategies are interconnected, ERAA identifies threatening aspects in the short run and TYNDP facilitates future-proven, target-aligned investments. .

---

<sup>147</sup> ENTSO-E, Implementation Guidelines for TYNDP 2024 (Version for ACER, European Commission and EU Member States Opinion | 9 April 2025) – [Link](#)

## ERAA and TYNDP exercises differ on how planned and forced outages are modelled

Given the fundamentally different scopes of the ERAA and TYNDP exercises, discrepancies exist on how planned and forced outages are modelled:

- | **Granularity:** The ERAA models planned and forced outages at the unit level, which is required for its hourly Monte Carlo simulations and unit commitment modelling, ensuring a high degree of operational realism<sup>148</sup>. The TYNDP, on the other hand, uses a more aggregated approach, typically at the technology fleet level, where fine-grained detail is less relevant given the focus on investment signals and long-term system needs.
- | **Planned outages optimisation:** In the ERAA, when TSOs do not provide detailed hourly maintenance schedules (some only submit annual outage rates), ENTSO-E centrally optimizes the planned outages to ensure consistency with system adequacy needs<sup>149</sup>. In contrast, TYNDP does not provide as in-depth information for forced and planned outages as ERAA does.
- | **Forced outages representation:** The ERAA models forced outages probabilistically, using Monte Carlo techniques to capture system risk under uncertainty, an essential feature for evaluating scarcity risk and reliability margins. In contrast, TYNDP applies deterministic outage time series for each technology, sufficient for representing average system behaviour across scenarios but not suitable for analysing extreme events.

## The two scenarios have different needs in terms of adequacy

From an adequacy perspective, the two studies diverge conceptually.

- | On the TYNDP side, the scenarios used for the infrastructure gaps identification exercise and the Cost-Benefit Analysis (CBA), are required to be adequate<sup>150</sup>, meaning they must be capable of meeting demand under reasonable stress conditions, keeping a LOLE between 2 and 3 hours. However, nothing in the TYNDP scenario building process guarantees that the collected datasets lead to an adequate supply mix. Therefore, if TYNDP scenarios do not meet this adequacy criteria, a Security of Supply loop (described in ENTSO-E Implementation Guidelines for TYNDP 2024<sup>151</sup>) is carried out on the scenarios before the CBAs.
- | Conversely, ERAA's purpose is to assess adequacy, not to guarantee it. As such, no adequacy constraint is applied during scenario development.

It is important to clarify that even within TYNDP, adequacy is not enforced during the initial scenario-building phase. The Security of Supply (SoS) loop, which ensures that the scenarios used in the

<sup>148</sup> ERAA 2024 Annex 2: Methodology, page 29,30.

<sup>149</sup> ERAA 2024 Annex 2: Methodology, page 29,30.

<sup>150</sup> 4th ENTSO-E Guideline for cost-benefit analysis of grid development projects (Final version approved by the European Commission) – [Link](#)

<sup>151</sup> ENTSO-E, Implementation Guidelines for TYNDP 2024 (Version for ACER, European Commission and EU Member States Opinion | 9 April 2025) – [Link](#)

infrastructure gaps identification exercise and in the CBAs meet adequacy standards, is conducted after the TYNDP scenarios are constructed and published. This means that during the scenario-building process, the generated scenarios may still be inadequate.

As a result, some TYNDP scenarios published by ENTSO-E and ENTSOG are highly inadequate. As an illustration, the table below displays the adequacy metric for the scenario National Trends+ 2040 of the TYNDP 2024, climate year 2009. If these values cannot be directly compared with the adequacy criteria the scenarios should meet (because these are defined on several hundred Monte Carlo years and not on one single climate year), they already give an indication on the magnitude of the capacity adjustments required in the SoS loop to make to scenarios fit-for purpose for the CBAs.

**Table 11 – Loss of load (LOL) duration, maximum power and energy not served (ENS) in the TYNDP 2024 National Trends+ scenario, climate year 2009<sup>152</sup>**

Market zone	LOL duration (hours)	LOL maximum power (GW)	ENS over the year (GWh)
PL00	116	10 082	257
LUG1	80	1 020	42
CZ00	65	4 346	108
DE00	47	83 270	1 236
MT00	34	135	2
DKE1	29	1 954	16
AT00	18	4 954	28
LUB1	17	37	0,48
LUF1	17	181	2,29
FR00	15	9 789	65
BE00	13	5 679	29
FR15	9	26	0,08
Others <sup>153</sup>	0	0	0

Moreover, no information about the net effect of the SoS loop on the European mix could be found in ENTSO-E’s publications (which poses a serious problem for the replicability of CBAs).

<sup>152</sup> Source: Artelys, based on ENTSO-E & ENTSOG TYNDP 2024 Scenarios – Outputs - NT+ 2040 Modelling Results – Climate Year 2009 (v40, downloaded on the 13<sup>th</sup> June 2025), worksheet ‘Hourly Market Data’ - [Link](#)

<sup>153</sup> All other market zones (excluding non-EU countries).

### Recommendation 18 – Transparency of the Security of Supply loop

This deviation between ERAA and TYNDP scenarios is justified by the different purposes of the two scenarios. However:

- | For a greater transparency and comparativeness between ERAA and TYNDP scenarios, the net effect of the SoS loop on the capacity mix should be published (as it for net effect of EVA in ERAA<sup>154</sup>).
- | For simplicity reasons and replicability of the CBAs, the outcome of the scenario building phase should already be fit-for-purpose for subsequent CBAs. Therefore, the authors of this report recommend that the SoS loop be integrated into the scenario building process, showing both results: the scenarios before and after the SoS loop.

### Commodity prices are consistent between the two scenarios

Regarding commodity prices, our analysis of the input parameters shows that most of the price assumptions are based on shared sources across both TYNDP and ERAA, as displayed in the table below.

**Table 12 – Comparison of ERAA and TYNDP commodity and carbon price assumptions (€/GJ)**

	ERAA 2023 prices 2030 <sup>155</sup>	TYNDP 2024 prices 2030 <sup>156</sup>
Hard Coal	1.78	1.8
Natural gas	6.30	6.3
Light Oil	11.74	11.7
Heavy Oil	9.63	9.6
Oil Shale	1.86	1.9
Lignite	1.40 - 3.10	1.4 – 3.1
Nuclear	1.68	1.7
CO2	113.4	113.4

<sup>154</sup> See ENSTO-E, European Resource Adequacy Assessment 2024 Edition – Annex 3: Detailed Results – [Link](#) (Figure 1, page 5)

<sup>155</sup> ERAA 2023 Annex 1: Input Data and Assumptions – page 22

<sup>156</sup> TYNDP 2024 Scenario methodology report – page 32

## The two scenarios differ significantly on the hydrogen supply

On hydrogen supply, ERAA and TYNDP scenarios differ significantly, both in terms of (1) modelling approach and (2) input data building process.

### In terms of modelling approach:

- | TYNDP provides a comprehensive hydrogen modelling framework, covering production, conversion, and storage. Hydrogen production is modelled through multiple pathways, including electrolysis and steam methane reforming (SMR), both with and without carbon capture and storage (CCS). The conversion side is also addressed, notably through the inclusion of fuel cells for reconversion into electricity<sup>157</sup>. The complete hydrogen dispatch is optimised to meet the hydrogen demand at the lowest cost.
- | In contrast, only electricity-grid-connected electrolyzers are represented in ERAA scenarios, and the dispatch of the electrolyzers is not optimised but simply simulated with an activation price on electricity: electrolyzers are producing hydrogen (and consuming electricity) at their maximum load when the electricity price is below the threshold and are not producing when the electricity price is above<sup>158</sup>. Hydrogen demand and infrastructure (storage, cross-border pipelines) are not explicitly modelled.

These deviations can partially be justified by the different objective of the two scenarios. However, even if hydrogen is not the focal point of ERAA, electricity-grid-connected electrolyzers' level of flexibility may in the future have an impact on the security of electricity supply. Yet, the results published on the last TYNDP and ERAA cycles show that the two scenarios took different assumptions on the level of flexibility that electrolyzers are supposed to operate during high-electricity-price hours:

- | In ERAA, electrolyzers stop running when electricity prices get above a certain threshold (e.g. 57.5 €/MWh<sub>el</sub> in 2030<sup>159</sup>). This means in particular that electrolyzers will never run during scarcity events, and also not at the same time of CCGTs (or any other fossil-based non-must-run power plant)<sup>160</sup>.
- | On the opposite, in the TYNDP, electrolyzers do sometimes run even during high electricity prices periods. For instance, in TYNDP 2024, NT+ scenario, in Germany, electrolyzers are

<sup>157</sup> TYNDP 2024 Methodology Report, from page 50 to 57.

<sup>158</sup> See ENSTO-E, European Resource Adequacy Assessment 2024 Edition – Annex 2: Methodology – [Link](#) (page 34).

<sup>159</sup> Value calculated by Artelys based on the assumptions published in ERAA 2024 – Annex 1: Input data & Assumptions and Annex 2:Methodology

<sup>160</sup> Under the assumptions of ERAA 2024, the Short Run Marginal Cost (SRMC) of CCGT is between 86 and 129 €/MWh<sub>el</sub> (values calculated by Artelys based on the assumptions published in ERAA 2024 – Annex 1: Input data & Assumptions and Annex 2:Methodology).

running during 44% of the hours when the electricity price is greater than 300 €/MWh<sup>161</sup>, representing an average electricity load of 7.6 GW during these hours.

The more flexible representation of electrolyzers in ERAA than in TYNDP can have several impacts on the key indicators of both scenarios:

- | In ERAA, electrolyzers' higher flexibility can lead to overestimating decommissioning and mothballing or underestimating new entry or life extension in the EVA (because it reduces the electricity consumption during the hours when technologies assessed through the EVA are supposed to produce, compared to TYNDP modelling).
- | In TYNDP, electrolyzers' lower flexibility can lead to overestimating the value of interconnection projects.

### **Recommendation 19 – Alignment of electrolyzers modelling between ERAA and TYNDP**

1. Although it is not possible to determine which of the two approaches is the most representative of how the system may behave in the future, the two scenarios would gain in consistency by adopting a common vision of the flexibility expected from electrolyzers connected to the electricity grid. Furthermore, workshops should be organised to compare the way electrolyzers behave in latest ERAA and TYNDP scenarios, assess the impact of these differences on the key indicators of the scenarios (adequacy indicators for ERAA, infrastructure gaps identification and CBA indicators for TYNDP) and determine the best modelling for both exercises. These workshops could be organised by a dedicated coordination group.
2. In terms of input data building process, grid-connected installed capacities are collected by ENTSO-E from electricity TSOs. In contrast, hydrogen-related assumptions are collected by ENTSG from the gas TSOs for TYNDP scenarios. Instead of two distinct data collection efforts, ENTSO-E and ENTSG should conduct one joint data collection on electrolyzers installed capacities, where electricity and gas TSOs of each country should align their view and provide one single value. The same value (for electricity-grid-connected electrolyzers) should then be used in both scenarios (similarly to the process already in place for the data collection on annual final energy demand).

---

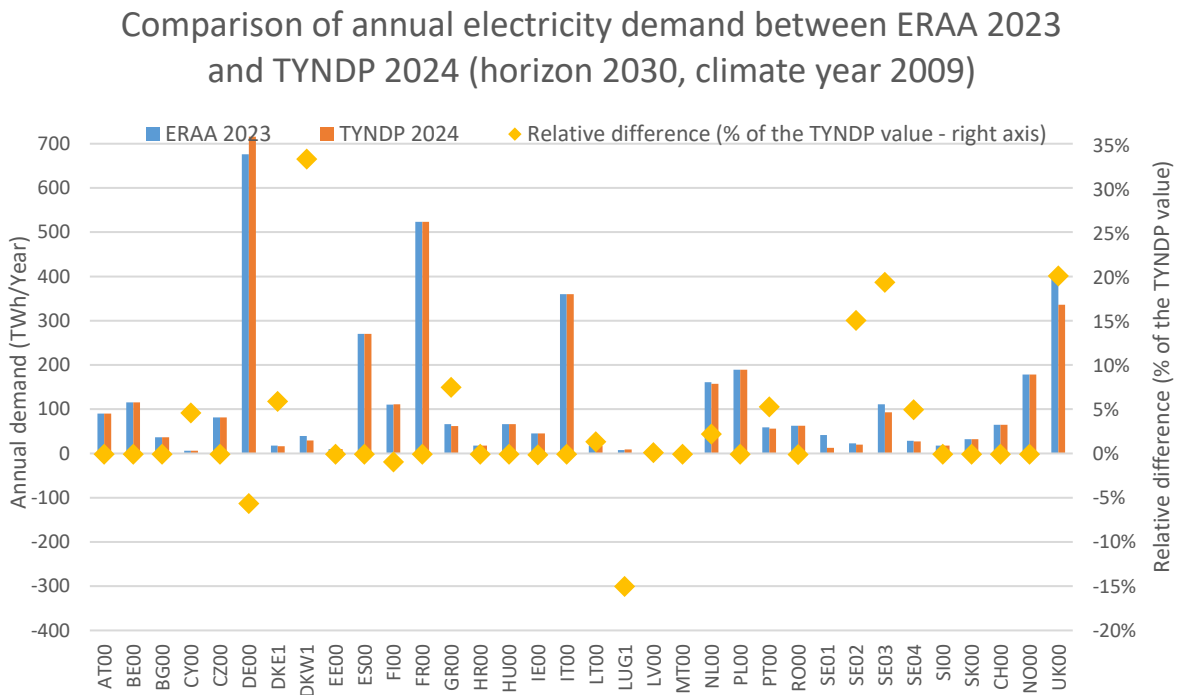
<sup>161</sup> Values calculated by Artelys based on the scenario hourly outputs *NT+ 2040 Modelling Results – Climate Year 2009* published by ENTSOs on TYNDP scenarios website ([link](#)), on the market node DE00 (Germany). Electricity prices in Germany are greater than 300 €/MWh for 519 hours (which represent 6% of the entire year). During 227 of these hours, the electricity consumption of the electrolyzers is greater than 0.

## 3.2 Demand

### Annual demand

The only final energy demand represented in ERAA scenarios is electricity. In particular, the hydrogen final demand is not represented in ERAA scenarios (the scenarios only include the electricity consumption of electricity-grid-connected electrolysers).

For both ERAA and TYNDP, electricity final energy demand values are provided by the national TSOs, based on their respective NECPs. An example of comparison of the annual electricity demand, between ERAA 2023 and TYNDP 2024, is provided in [Figure 44](#).



*N.B.:* For SE01 the relative difference is +223% and is not appearing in the graph because the difference with the other values is too high and adding it would decrease the graphical quality of the graph.

**Figure 44 – Annual electricity demand comparison: ERAA 2023 and TYNDP 2024 (on the horizon 2030 and climate year 2009)<sup>162</sup>**

Annual demand projections for the year 2030 and climate year 2009 are:

<sup>162</sup> Source: Artelys, based on *Demand Scenarios TYNDP 2024 After Public Consultation* file downloaded on TYNDP 2024 download page ([link](#)) and Demand Datasets download on ERAA 2023 download page ([link](#)). For the sake of clarity, Italian and Norwegian bidding zones are aggregated. Market nodes FR15 (Corsica), GR03 (Crete), LUB1, LUF1 and LUV1 (Luxembourg specific bidding zones) and UKNI (Northern Ireland) are not represented on the graph.

- | Perfectly aligned<sup>163</sup> between ERAA 2023 and TYNDP 2024 for 16 Member States<sup>164</sup>.
- | Higher in ERAA 2023 than in TYNDP 2024 for 8 Member States and the United Kingdom. The highest absolute difference is in the UK (+ 68 TWh). The highest relative difference is in SE01 (+223% - not displayed on the graph).
- | Lower in ERAA 2023 than in TYNDP 2024 for 2 Member States. The lowest absolute difference is in Germany (- 40 TWh). The lowest relative difference is in Luxembourg (LUG1) (-15%).

The differences observed between the ERAA 2023 and TYNDP 2024 demand levels across several Member States are noteworthy, particularly given that the two reports were published only a year apart. These variations in demand projections raise questions about the consistency of assumptions and the alignment between the two exercises. Offering a clear and transparent explanation for these differences should constitute the basis to reinforce stakeholder confidence in the modelling approach and data governance.

However, the lack of sufficient transparency regarding these divergences makes it difficult for this report to clearly identify their underlying causes. Yet, the differences on the data collection timelines between both exercises should not be justification for significant divergences in demand between the central scenario used for TYNDP and for ERAA, except maybe in cases where new NECPs were published between the two reports.

The absence of publication of version tracking of the input databases (as recommended as a fallback option in the [Recommendation 16](#)), with release IDs corresponding to the different milestones of the scenarios' development process, and release notes for each version specifying the changes compared with previous versions, makes it impossible to provide a clear explanation of the observed deviations.

---

<sup>163</sup> Relative difference lower than 0.1%

<sup>164</sup> For France, the demand projections are perfectly aligned for the market node FR00 but slightly differ for FR15 (Corsica) – not displayed on the graph. France has nevertheless been counted as “perfectly aligned”.

Additionally, if the data collection process on final energy demand used to be aligned between ERAA and TYNDP scenarios until ERAA 2023 and TYNDP 2024 cycles (Excel templates filled in by TSOs<sup>165</sup>), the introduction of the ETM in the TYNDP scenario building process (from the TYNDP 2026 cycle for the National Trends+ scenario) has created a gap between the tools used in both exercises.

### **Recommendation 20 – Alignment on annual electricity demand between ERAA and TYNDP**

Annual electricity demand assumptions should be aligned between ERAA and TYNDP exercises, as both should be based on the NECPs. Therefore, any deviation between the assumptions of the two exercises would necessarily mean that at least one of them deviates from the NECP. Such deviations should be made transparent and justified by the TSO (as described in [Recommendation 3](#)) and validated by the NRAs (as described in [Recommendation 6](#)).

For future ERAA and TYNDP cycles, the data collection framework (including the tools used for the data collection, instructions shared to TSOs, sanity checks and governance<sup>166</sup>) should be revised to ensure that discrepancies between ERAA and TYNDP input data are avoided. Ideally, the same tools should be used for collecting data for both exercises (at it was before the introduction of the ETM for demand data collection on the TYNDP side), and TSOs should only have to fill in data once for both exercises. The revised framework should include clear guidelines on acceptable assumption changes, disclosure of methodological adjustments and their impact on the consistency between ERAA and TYNDP demand input.

For the on-going scenario building cycles (ERAA 2025 and TYNDP 2026), a particular attention should be drawn on potential discrepancies on electricity annual final energy demand assumptions between ERAA and TYNDP, given the recent introduction of a gap between both processes caused by the introduction of the ETM on the National Trends+ scenario.

- | For future cycles, if the ETM delivers on his promises, its utilisation could be extended to ERAA, for greater convergence and synergies between the processes.

---

<sup>165</sup> Source: Interviews between Artelys and ENTSOs.

<sup>166</sup> see [Recommendation 6 – Systematic scrutiny and validation by the NRAs of the input data provided by the TSOs](#)

## Hourly demand

In the modelling phase, both TYNDP and ERAA must convert annual electricity demand into hourly time series, a step essential for hourly-based simulation models. For this purpose, both exercises use the same tool, the Demand Forecasting Tool (DFT)<sup>167</sup>. However, in the Innovation Roadmap for TYNDP 2026, the use of the Energy Transition Model to generate hourly electricity demand time series has been proposed, replacing the Demand Forecasting Tool (DFT) currently in use. This methodological shift marks a significant divergence from the ERAA process, which is expected to continue using the DFT.

It is important to underline that such a change introduces an increased risk of inconsistencies between the hourly profiles used in the two exercises. Even minor differences in assumptions or algorithms between the ETM and the DFT can lead to diverging hourly time series, despite starting from similar annual demand values. This divergence could, in turn, affect downstream modelling results such as dispatch patterns, adequacy assessments, and infrastructure needs. The main inputs of the DFT are:

1. **Historical hourly consumption timeseries** and historical climate data on recent years, in order to train the models.
2. **Climate data for a large number of climate years** (~35) to project the models trained as described above and obtain a large number of electricity load profiles for different climate realisation.
3. **Information about how the structure and flexibility of the demand is supposed to evolve** (EVs, heat pumps, data centres, other types demand-side flexibilities) to perform load adjustments.

The two first inputs mentioned above are shared and aligned between ERAA and TYNDP building process. Regarding the climate data used to project the model on a large number of climate realisation, ENTOS-E has recently carried out a significant update, with the integration of the effects of climate change. This update materialise in a new version of the Pan-European Climate Database (PECD4), where the climate years are not labelled from 1982 to 2016 as previously but from 2025 to 2060. This update has introduced a temporary gap between ERAA 2024 (which relies on the update PECD) and TYNDP 2024 (which relied on the previous version). This gap will be filled from the next cycles.

---

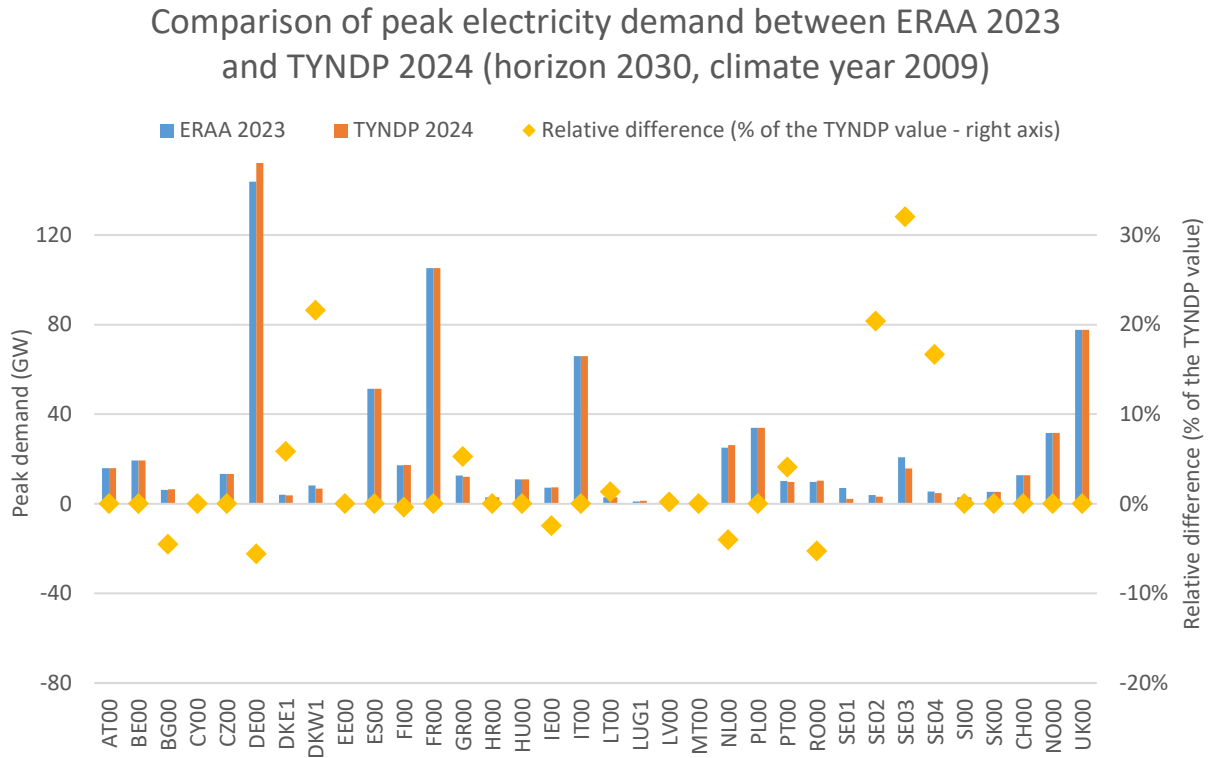
<sup>167</sup> TYNDP 2024 Methodology Report and ERAA 2024 Annex 2: Methodology.

For both TYNDP and ERAA, some specific TSOs (e.g. Poland, France and Belgium for the TYNDP 2024) have decided to build the hourly load profiles on their own tools, and to provide the time series to ENTOSs, for sake of consistency with their national exercises.

### Differences of peak demand

The differences in terms of peak demand between ERAA 2023 and TYNDP 2024 are illustrated on N.B.: The value of the relative difference for SE01 (which is not present on the graph) is equal to +217%.

Figure 45.



N.B.: The value of the relative difference for SE01 (which is not present on the graph) is equal to +217%.

**Figure 45. Peak electricity demand comparison: ERAA 2023 and TYNDP 2024 (on the horizon 2030 and climate year 2009)<sup>168</sup>**

The peak demand can be seen as the combination of annual demand projections and hourly demand profiles. Surprisingly, the differences in terms of peak demand between ERAA 2023 and TYNDP 2024 are not aligned with the differences in terms of annual energy demand projections. In particular:

- Three Member States (Bulgaria, Ireland, and Romania) have perfectly aligned<sup>169</sup> annual demand projections between ERAA 2023 and TYNDP 2024, but different peak demand projections.

<sup>168</sup> Source: Artelys, based on *Demand Scenarios TYNDP 2024 After Public Consultation* file downloaded on TYNDP 2024 download page ([link](#)) and Demand Datasets download on ERAA 2023 download page ([link](#)).

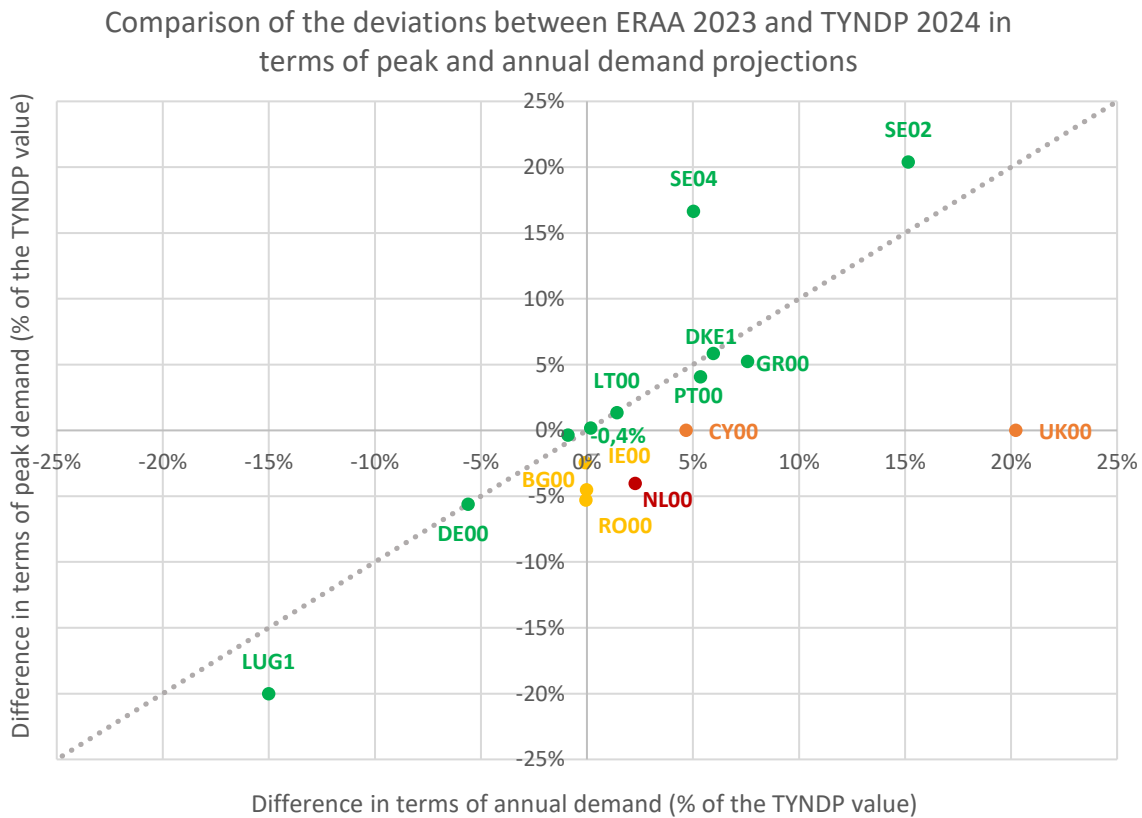
For the sake of clarity, Italian and Norwegian bidding zones are aggregated. Market nodes FR15 (Corsica), GR03 (Crete), LUB1, LUF1 and LUV1 (Luxembourg specific bidding zones) and UKNI (Northern Ireland) are not represented on the graph.

<sup>169</sup> Difference lower than 0.1%.

- | One Member State (Cyprus) and the United-Kingdom have different annual demand projections between ERAA 2023 and TYNDP 2024 but perfectly aligned peak demand projections.
- | One Member State (the Netherlands) has higher annual demand in ERAA 2023 than in TYNDP 2024 (+3.6 TWh/year / +2.3%) but lower peak demand (-1 GW / -4%).

Besides the above six situations:

- | Thirteen Member States are perfectly aligned between ERAA 2023 and TYNDP 2024 both in terms of annual and peak demand projections.
- | For the nine remaining Member States, the variations in terms of peak demand are consistent with the variations in terms of annual demand between ERAA 2023 and TYNDP 2024, as represented in green on the figure below.



**Figure 46 – Comparison of the deviations between ERAA 2023 and TYNDP 2024 in terms of peak and annual demand projections.**

### Recommendation 21 – Alignment on peak electricity demand between ERAA and TYNDP

Peak demand is a highly sensitive input parameter for ERAA, as scenario adequacy results are strongly influenced by it, as underlined in Table 2. Therefore, the misalignment between the values proposed in TYNDP 2024 and ERAA 2023 is a cause for concern. For the nine cases mentioned above, where the misalignment in peak demand is consistent with that of annual demand, the situation is somewhat more understandable, though still problematic. However, for the six cases where no such correlation exists (i.e., where peak demand deviates significantly despite annual demand being aligned) the issue becomes significantly more concerning.

Given the critical role of peak demand in adequacy assessments, it is strongly recommended that this parameter be aligned between TYNDP and ERAA, unless clear and well-justified reasons are provided. These reasons should be explicitly linked to the differing objectives or methodological needs of the two exercises which, in the present case, have not been articulated.

Regarding the shift from the DFT to the ETM, and given the importance of harmonized input assumptions, particularly for parameters like hourly demand which strongly influence both system adequacy and infrastructure planning, a careful evaluation of the methodological differences between ETM and DFT is recommended before fully implementing this innovation in TYNDP 2026.

### Number of climate years represented

The number of climatic years used in subsequent modelling steps also differs significantly between the two exercises, depending on their purpose and scope.

- | In ERAA, more than 30 climate years are simulated in the Economic Dispatch phase to capture a wide range of possible weather conditions, particularly to assess system performance under extreme climate events and resource scarcity.
- | In contrast, TYNDP 2024 took a more limited approach: during the scenario building process, ENTSO-E and ENTSG only published results for on single climate year (2009) on National Trends+ scenario<sup>170</sup>, while the Deviation Scenarios (DE and GA) were run using three climate years: 1995, 2008, and 2009. This reflects a different modelling objective, with TYNDP

---

<sup>170</sup> In later steps of the TYNDP process (after once scenario building is over), ENTSO-E do use additional climate years on the scenario National Trends+, notably:

- | For the SoS loop (where ENTSO-E's Implementation Guidelines for TYNDP 2024 mention "several hundred of MC [Monte Carlo] years")
- | For the CBA (where ENTSO-E's Implementation Guidelines for TYNDP 2024 mention the use of three climate years (1995, 2008 and 2009) for the B1 to B5 indicators and 34 climate years for the B6 indicator).

However, in the TYNDP scenario building process, the only climate year mentioned for the National Trends+ scenario is 2009.

scenarios prioritizing system development and infrastructure needs rather than short-term adequacy under extreme conditions.

These deviations between ERAA and TYNDP seem reasonable given the different objective of the two scenarios: ERAA aims to assess adequacy under uncertainty and extreme weather conditions, whereas TYNDP focuses on long-term infrastructure planning under different policy and technology scenarios.

### **Recommendation 22 – Alignment on the number of climate years published between TYNDP scenario building process and TYNDP CBAs**

The main recommendation on the number of climate years is, for the TYNDP, to align the number of climate years represented and published in the scenario building process with the needs for the subsequent steps of the TYNDP process (notably the CBAs). For example, for TYNDP 2024, if indicators B1 to B5 of the CBAs are computed on three climate years (1995, 2008 and 2009), the results of the scenarios building phase should be published at least for the same climate years.

On ERAA's side, the probabilistic assessment of adequacy risks could benefit from refining its climate year selection. Rather than using the full historical dataset by default, applying statistical clustering could help ensure that the chosen years efficiently capture the full spectrum of relevant climate conditions, while reducing redundancy and computational burden. Defining such clusters could enable to slightly reduce the number of climate years without losing in probabilistic accuracy, and in this way reduce the gap between ERAA and TYNDP. Nevertheless, the authors of this report acknowledge that this topic is very complex, and that it will anyway not be possible to fill the gap between ERAA and TYNDP on the number of climate years.

## 3.3 Network

From a network perspective, several important differences exist between TYNDP and ERAA, both in terms of modelling approach and in terms of inputs construction process.

In terms of modelling approaches:

- | TYNDP models the electricity network using Net Transfer Capacities (NTCs) exclusively<sup>171</sup>, applying simplified representations of cross-border exchange limits between bidding zones.
- | In contrast, ERAA employs a more detailed approach, incorporating Flow-Based (FB) domains. Initially, FB domains were applied only to the CORE region (up to ERAA 2023), but starting from the ERAA 2024 cycle, the Nordic region has also been included<sup>172</sup>. The choice to use FB

<sup>171</sup> TYNDP 2024 Methodology Report, page 14.

<sup>172</sup> ERAA 2024 Annex 2: Methodology, page 24.

Some simplifications are still implemented compared to what happens in real markets in order to keep reasonable computation time, such as the selection of representative hours to compute flow-based domains.

modelling in ERAA reflects the aim to better replicate the operational realities of the European transmission system, particularly in congested regions, where the interaction between internal and cross-border flows significantly affects market outcomes.

### **Recommendation 23 – Alignment on network representation between ERAA and TYNDP**

A way to further align ERAA and TYNDP scenarios could be to implement flow-based modelling in the TYNDP as well. In our view, this should nevertheless only be implemented if the benefits in terms of accuracy of System Needs and CBAs outweighs the disadvantages. Therefore, before taking any decision on the relevance to implement flow-based in the TYNDP, at least the following questions should be explored, supported by test-runs:

- | How would flow-based scenarios be integrated into the TYNDP System Needs and CBA processes? For example, for CBAs, the following questions are important:
  - Would the impact of the projects within the flow-based region assessed with an NTC or flow-based approach?
  - If flow-based, who would be in charge of calculating the impact of each individual project on the flow-based domains?
  - Would every project promoter be in charge of computing the individual impact of its project on the flow-based domain?
  - If the flow-based domains variations are computed individually by each project promoter, how to ensure that the estimations are consistent?
  - If the flow-based domains variations are computed centrally by ENTSO-E, how would this impact the TYNDP overall timeline?
  - How would this impact Identification of System Needs studies (bearing in mind that capacity expansion with flow-based modelling is technically very challenging).
- | How would this update impact the value of the System Needs and CBA indicators?
- | Would the CBA results remain interpretable to award the PCI/PMI status and understandable (including by the project promoters)?
- | Which impact would this update have on the computational time?

## Implementation of the 70% rule in ERAA

In terms of capacity allocation rules, ERAA also integrates the 70% minimum capacity requirement<sup>173</sup>, as defined in Article 16(8) of Regulation (EU) 2019/943<sup>174</sup>, which mandates that at least 70% of the physical transmission capacity on each cross-border line be made available for cross-zonal electricity trading. However, one NRA reported<sup>175</sup> that assuming that the 70% rule is systematically achieved on cross-border capacities is not necessarily relevant, given the fact that this rule is commercial and does not actually free up interconnection capacity from a physical and adequacy point of view.

In the TYNDP framework, no mention of the 70% rule could be found in the documentation. Confirmation of that is point (36) of the ACER Opinion on the draft of the TYNDP 2024<sup>176</sup>.

In ERAA 2024, the 70% requirement<sup>177</sup> is implemented via a post-processing step applied to the flow-based domains, particularly within the Core Capacity Calculation Region (Core CCR). The underlying principle is to ensure that non-market flows (such as internal flows and loop flows) do not use more than 30% of the transmission capacity, thereby reserving 70% for market exchanges.

The implementation begins with ENTSO-E computing the flow-based domains using Power Transfer Distribution Factors (PTDFs) and Remaining Available Margins (RAMs) for each Critical Network Element under Contingency (CNEC). These form the basis for a set of linear constraints, where the product of the PTDF matrix and the zonal net positions must be less than or equal to the RAM for each CNEC, defining the FB domain's shape.

The 70% rule is then enforced through a post-processing adjustment:

- | All zonal net positions are set to zero, simulating a condition with no cross-zonal trade.
- | This isolates internal and loop flows on each CNEC.
- | For each CNEC, ENTSO-E checks whether the internal flow under this "zero trade" scenario exceeds 30% of the RAM.
- | If it does, the RAM is increased so that internal flows do not exceed 30%, thereby ensuring that the remaining 70% is available for market exchanges.

## Differences in network data construction

The network modelling approaches used in TYNDP and ERAA also differ significantly from a data construction standpoint<sup>178</sup>:

- | For TYNDP, each TSO's market modelling department provides ENTSO-E with a projected vision of NTC values for each target year. These NTCs are then used to construct the Electricity

---

<sup>173</sup> ERAA 2024 Annex 2: Methodology, page 25,26.

<sup>174</sup> See [Link](#)

<sup>175</sup> Source: Artelys' survey to NRAs.

<sup>176</sup> See [Link](#)

<sup>177</sup> ERAA 2024 Annex 2: Methodology, page 26.

<sup>178</sup> Source: interviews between Artelys and ENTSO-E.

Reference Grid, taking also into account projects submitted by TSOs and 3<sup>rd</sup>-party project promoters, as described in Task 1, Chapter 1.2.2.1. The result is a consistent and high-level view of expected cross-zonal capacities, aligned with the TYNDP's infrastructure planning objectives.

- | For ERAA, the network input data (flow-based domains and NTCs for the markets zones not included in the flow-based regions) are not directly collected from the TSOs, as it is for the TYNDP, but are computed centrally, based on ENTSO-E's Common Grid Model. ENTSO-E's Common Grid Model is itself built in a bottom-way based on data on grid projects provided by each TSO. However, it should be highlighted that the contact point within each TSO in charge of providing the grid data for ENTSO-E to build the Common Grid Model (identified as *grid data correspondent*) is generally a different person from the *market data correspondent* in charge of providing all other market related inputs (information on demand, supply, NTCs for the TYNDP etc.).

Moreover, further adaptation by ENTSO-E are often required. For example, if grid data is provided for 2027, but ERAA simulations are focused on 2028, adjustments must be made.

#### **Recommendation 24 – Alignment on grid assumptions building process between ERAA and TYNDP**

It should be acknowledged that, given the differences on the network modelling approaches (already addressed in [Recommendation 23](#)), the nature of the input parameters is different between the two exercises (NTC values for TYNDP vs. flow-based domains for ERAA), and therefore the input parameters cannot be fully aligned. Nevertheless, the grid input building process should still be harmonised between the two exercises, in order to ensure that NTC projections provided for TYNDP and flow-based domains used for ERAA reflect a consistent and unique vision of how the network will evolve (e.g. that the same projects are considered in both projections etc.).

To address this, the following set of recommendations could be considered:

- | Best solution: Establish a harmonised and coordinated grid assumption building process between ERAA and TYNDP (i.e. having the same team(s) in charge of determining both NTC and flow-based domains projections, relying on a unified network model). This solution would ensure that the flow-based domains used in ERAA and the NTCs used in TYNDP are built on the same underlying base year and consistent projects pipeline.
- | First alternative: If full alignment is not feasible due to modelling constraints, the following safeguards should be put in place:
  - Each entity in charge of determining projected NTC and/or flow-based domains should publish the underlying assumptions on grid evolutions considered for each target year (showing starting capacities (base year) and new projects with commissioning timelines). Then, the differences in underlying assumption should be made explicit, justified or resolved.

- Moreover, ENTSO-E should conduct internal comparisons:
    - Derive NTCs from the grid model data used for flow-based domains projections for ERAA and compare with TYNDP NTC values submitted by TSOs.
    - Report any inconsistencies and clarify their source (e.g. data update timing, differing project assumptions).
- | Fallback solution: If structural or timing constraints prevent better alignment, both ERAA and TYNDP reports should contain a dedicated section explaining where their grid assumptions differ, why those differences exist and what impact the divergence may have on scenario results. Furthermore, the inclusion of visuals or tables showing project-by-project differences is recommended.

### 3.4 Stakeholder engagement processes

TYNDP and ERAA also differ significantly in their stakeholder consultation processes. TYNDP features a higher level of stakeholder engagement, both in frequency and structure<sup>179</sup>. Since the 2024 edition, a dedicated Stakeholder Reference Group (SRG) has been established, providing ongoing input throughout the scenario-building process. In addition, TYNDP organizes stakeholder roundtables, which offer focused discussions on specific topics, while these are not present in ERAA. Furthermore, TYNDP generally includes more rounds of public consultation than ERAA. In contrast, ERAA stakeholder involvement is limited, mainly consisting in a Call of Evidence on input data and a public consultation on the scenarios results<sup>180</sup>. Moreover, the number of feedback collected from stakeholders during last ERAA cycle is also quite low. For instance, eleven stakeholders replied to ERAA 2023 public consultation<sup>181</sup>.

This limited interaction may hinder transparency, reduce stakeholder buy-in, and weaken alignment with national and European planning processes.

This difference can partially be explained by the TYNDP's longer timeline, which allows for greater interaction with external stakeholders. ERAA, being an annual exercise, operates under tighter time constraints, limiting the extent of its consultation phases.

---

<sup>179</sup> TYNDP 2024 Scenarios Package (all public documents for TYNDP 2024)

<sup>180</sup> ERAA 2023 – Presentation of results and key messages, 10<sup>th</sup> January 2024, slide 30 – [link](#)

<sup>181</sup> [Link](#)

## Recommendation 25 – Stakeholder engagement process in ERAA

Two options could be considered to improve the stakeholder engagement process in ERAA:

- | Extend the remit of the SRG (i.e. the group of experts that follow all the processes in TYNDP) to ERAA, in order to provide feedback to ENTSO-E on ERAA scenarios, and to ensure stakeholders better understand the complexity of the ERAA exercise. From the feedback collected in the context of this study, this way of involving stakeholders can bring efficiency in consultation processes. Given the overlap between the TYNDP and ERAA processes, the “Terms of Reference” of the SRG could be extended to include ERAA’s scenario building process. An alternative option could be to set up a SRG dedicated to ERAA, but this would limit its ability to identify and provide inputs on potential deviations between TYNDP and ERAA scenarios.
- | Implement a higher number of public consultation periods but with a shorter duration compared to TYNDP ones. The efficiency and effectiveness of the latter can be improved with pre-consultation webinars (webinars in which the data to be consulted is fully explained) and fast response feedback loops (quicker and more efficient channels of information exchange between TSOs, ENTSO-E and ENTSOG, and stakeholders).

It should nevertheless be acknowledged that some of these recommendations may be difficult to implement on an annual cycle (which does not necessarily allow stakeholders sufficient time to provide feedback). This links to [Recommendation 9](#).

## 3.5 Compliance with EU climate goals

While TYNDP includes a dedicated methodology to ensure that scenarios align with EU climate and energy targets (the gap filling methodology<sup>182</sup>, which is broadly described in section [1.3.2.2. TYNDP gap filling methodology](#)), ERAA does not incorporate such a mechanism.

However, it is important to recall and emphasize that, by design, the current gap filling methodology (as used in TYNDP 2024) does not impact electricity or hydrogen parameters. As a result, the current gap filling methodology does not introduce any deviation between ERAA and TYNDP.

Therefore, even though the very concept of compliance with EU climate targets is difficult to apply to ERAA, since the targets are system-wide (covering all energy carriers) and ERAA only covers parts of it, one could argue that ERAA scenario is also aligned with EU climate goals, as long as it is aligned with the TYNDP scenarios (or at least should be aligned) on the electricity and hydrogen demand and supply assumptions.

---

<sup>182</sup> TYNDP 2024 Storyline Report, page 25,26,27.

## 4 Task 4 - Definition of a process and method to filter and validate scenario inputs

While recent improvements in data transparency on ERAA and TYNDP input data should be acknowledged<sup>183</sup>, only limited information is available regarding the sources used and the criteria and process by which these sources were selected. However, complete transparency regarding input data requires not only providing parameter values (as is already the case for much of the input data for both exercises – as outlined in the first section of this report, even if improvements remain to be done<sup>184</sup>), but also justifying the values chosen, for example by providing the source and comparing the value selected with other sources in the literature.

In this context, the objective of the present task is to develop a methodology for validating the sources used to define the inputs of the TYNDP and ERAA scenarios. The methodology described below is primarily designed to be applied to the input parameters determined centrally by ENTSO-E and ENTSG, but could be extended to parameters determined by the national TSOs<sup>185</sup>.

The results of this work must be published in an accessible and understandable format (e.g. Excel template), in order to enable any stakeholder to understand and replicate the process followed by ENTSO-E and ENTSG to determine the different assumptions adopted.

The proposed methodology would have two types of benefits for the scenario building process:

- | The methodical approach could support informed decision on the sources to be used as an input of the scenarios and therefore **improve the quality of input parameters of the scenarios**.
- | This approach would also be a way for ENTSO-E and ENTSG to report in a unified way how the choice of the scenario inputs are made and therefore **improve the transparency of the scenario building processes**. In this perspective, the template provided as an annex (with the example on the four parameters) should not only be used to choose the sources of the input parameters but should also be published.

The proposed methodology consists of three steps described below. This methodology has been applied to four examples of parameters agreed upon with ACER:

- | Efficiency of electrolysers.
- | Natural gas price.
- | Onshore wind annual capacity factor in Germany.
- | Investment cost of hydrogen pipelines.

The illustrative application of the proposed methodology to these four parameters is available as an annex (Excel format) to the present report.

<sup>183</sup> For example, the TYNDP 2024 provided a fine granularity of input and output data, allowing for a more accurate reproduction of the scenario compared to previous editions

<sup>184</sup> See for instance [Recommendation 10](#), [Recommendation 13](#), [Recommendation 15](#), [Recommendation 18](#), [Recommendation 20](#) and [Recommendation 21](#).

<sup>185</sup> Regarding the justification of national assumptions provided by the TSOs, see also [Recommendation 3](#).

## 4.1 Step 1 – Selection of a set of sources providing values for each input

The objective of the first step is to identify a set of sources for each considered input. These sources can be public (e.g., based on a report published online) or provided directly by stakeholders, such as TSOs, the scenario Stakeholder Reference Group. For each input, a set of information is collected, including:

- | The origin of the source (whether it is an original/primary source or if relies on another institution's publication)
- | **NB:** in case of a non-original source (e.g. a report citing another source), this second “parent” source should be, to the extent possible, added to the benchmark. The non-original source can still be left in the benchmark as an indicator of reliability of the primary source.
- | The public accessibility of the source and its publication date
- | The public accessibility to explanation provided on how the input value is derived, including the methodology, assumptions, and data processing steps used to establish it
- | The context of the source: the type of technology for which the input value is being collected (if applicable), relevant geographical area (if applicable) and relevant time horizon.
  - For example, if the methodology is applied to the CAPEX on wind and solar technologies, and that the objective is to determine a unique value across the EU sources specifying that they apply to the European Union would get a higher grade than a source coming from a specific EU Member State. On the other hand, if the objective is to determine differentiated values for the across Member States, then country-specific sources would get a higher grade.
- | Additional characteristics helping understand the scope of the value, and to determine whether a source corresponds to the target. The list of additional characteristics will depend on the parameter.

As an illustration, some points to be checked to ensure that a source is relevant are provided for the four examples on which the methodology has been applied to, as part of this project.

- | For electrolyzers efficiency:
  - Are the values provided in Net Calorific Values/Lower Heating Values (LHV) or in Gross Calorific Values/Higher Heating Values (HHV)?  
**NB:** this check should be applied to any input data related to methane or hydrogen quantities (efficiencies, potentials, demand etc.)?
  - Which electrolyser technology does this value refer to? Different technologies (PEM, alkaline, SOEC) have varying efficiencies
- | For natural gas price:
  - What type of natural gas is considered? Price may vary depending on the reference market

- Does the price refer to the raw gas, or does it include midstream costs such as transport, regasification, and associated infrastructure?
- | Onshore wind annual capacity factor in Germany:
  - Does the value represent theoretical generation potential or electricity generation volume (also including outage, maintenance and/or curtailment periods)?
  - Does the value correspond to the right type of wind power: onshore or offshore.
  - Does the value refer to the average capacity factor of the whole generation portfolio operational at a given time horizon, or to the capacity factor of new wind power plants commissioned at that horizon?
- | Investment cost of hydrogen pipelines:
  - Is the value expressed in €/km/MW HHV or in €/km/MW LHV?
  - What pipeline size does the value correspond to? Larger pipelines benefit from economies of scale by transporting higher capacities, which reduces the cost per unit of energy transported.
  - Does the value include cost of compressors?
  - Do the value represent repurposed from existing gas infrastructure or newly built infrastructure?
- | For other parameters, relevant verifications can be:
  - For PV installed capacities, are the values DC (before the inverter) or AC (after the inverter)?
  - For methane and hydrogen consumption, are the values including non-energy consumptions? Are the values including the consumption of hydrogen produced as a by-product?
  - For consumption of any energy carrier: are network losses included?

## 4.2 Step 2 – Quality screening and definition of minimum standards

In this step, the evaluation of each identified value begins with a preliminary screening to determine whether it should be excluded based on disqualifying criteria. Values are discarded if they meet any of the following conditions:

- | The source is too old (a cut-off year should be defined).  
NB: the cut-off year should be adapted depending on the parameter, depending notably on whether the parameter changes over time (as a general rule, economic parameters tend to change over time, while physical parameters are more stable – although there are exceptions). The number of sources available in the literature (stricter cut-off year can be set for parameters for which there is extensive literature), and the publication date of the sources available (if all the sources are more than four years old, setting a cut-off year at three years is irrelevant).
- | The value significantly deviates from other available values or appears clearly unrealistic.

- | The scope of the source is not relevant.  
Example: source is related to repurposed hydrogen pipelines, while if the methodology aims at determining the CAPEX of new-built hydrogen pipelines.
- | The scope of the source is not sufficiently specified to ensure its comparability with other values.  
Example: for an electrolyser's efficiency, source not specifying if the unit is in NCV or GCV for hydrogen.

After this initial filtering, the remaining values are compared with one another. Outliers that still diverge substantially from the rest may also be excluded from the analysis.

### 4.3 Step 3 – Scoring and ranking of the relevant sources

The objective of this step is finally to determine which source should be used among the different sources which passed the minimum quality standards.

To that end, the sources are rated on a scale from 1 (poor) to 4 (very good) according to several dimensions. The following dimensions could be considered:

- | **Type of the institution** or author who determined the value: academia, independent agencies (e.g. IEA), sectoral-specific organisations (incl. NGOs) representing industry (e.g. EHB), other NGOs or others.
- | **Public source**: does the information come from a fully public, a partially public source or a non-public source.
- | **Quality of the methodology and relevance to the context**: criteria determining the score obtained in this dimension includes:
  - **The closeness of the context** in which the values has been determined with the context of TYNDP or ERAA scenarios (reference year, geographical scope, and plausibility of the scenario from which the value is drawn).
  - **The publication date** of the source (recent source would get a higher score, especially for the parameters evolving rapidly)
  - **The quality and transparency of the methodology**. Sources with poorly documented methodology, which may not allow for reproduction or verification would get lower scores. For example, the level of detail provided on the methodology to determine the overall CAPEX for hydrogen pipelines in the TYNDP 2024 does not enable to retrieve easily the value provided by ENTSO-E and ENTSOG. Therefore, the methodology is not transparent.
  - **The recognition of the methodology by third parties**: peer-reviewed and frequently used reports/articles (e.g. cited in articles or used as an assumption of other modelling exercises) would get a higher grade.

NB: scores (from 1 to 4) attributed to the different sources which result from a qualitative assessment should be duly explained and justified, in order to enable any stakeholder to replicate the process followed by ENTSO-E and ENTSOG.

Finally, the different input values are ranked. Each value is assigned a score based on the weighted sum of the ratings given during the quality screening step.

When a parameters have several categories (for instance for hydrogen pipelines, where values may differ by size, whether the pipeline is newly built or repurposed, and whether it is offshore or onshore), the above process is applied separately to each sub-category, but should be applied in a consistent way to all categories in order not to introduce bias (for instance not consider optimistic value for large pipelines and pessimistic value for smaller pipelines).

## 5 Annex

### 5.1 List of public documents studied

#### | TYNDP 2024

- TYNDP 2024 Scenarios Report ([Link](#))
- TYNDP 2024 Scenarios Methodology Report ([Link](#))
- TYNDP 2024 Scenarios Storyline Report ([Link](#))
- TYNDP 2024 Scenarios Report Data Figures ([Link](#))
- TYNDP 2024 Annex to the Final Scenarios Report ([Link](#))
- All input files for the TYNDP 2024 scenarios
- All output files for the TYNDP 2024 scenarios
- TYNDP 2024 Consultation Summary Report ([Link](#))
- ACER TYNDP Scenarios Guidelines ([Link](#))
- ACER Opinion (No 05/2024) on the compliance of ENTSO-E and ENTSOG draft TYNDP 2024 Scenarios Report with ACER Scenarios Guidelines ([Link](#))

#### | TYNDP 2026

- TYNDP 2026 Scenario Timeline ([Link](#))
- TYNDP 2026 Stakeholders Engagement plan ([Link](#))
- TYNDP 2026 Kick-off Workshop Presentation ([Link](#))
- TYNDP 2026 Scenarios Process Update Webinar ([Link](#))

#### | ERAA 2023

- ERAA 2023 Annex 1: Input Data and Assumptions ([Link](#))
- ERAA 2023 Annex 2: Methodology ([Link](#))
- ERAA 2023: Executive Report ([Link](#))
- ERAA 2023: Detailed Results ([Link](#))

- ERAA 2023 Stakeholder Interactions (Slides) ([Link](#))
- Methodology for the European resource adequacy assessment ([Link](#))
- Decision No 06/2024 of the ACER of 2 May 2024 on the ERAA for 2023 ([Link](#))

| ERAA 2024

- ERAA 2024 Data Collection Guidelines ([Link](#))
- ERAA 2024 Stakeholder Interactions ([Link](#))

| ERAA 2025

- ERAA 2025 Call for Evidence on Input Data

| Additional documents

- Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity (recast) ([Link](#))
- Regulation 2022/869 (TEN-E Regulation) ([Link](#))

## 5.2 Questionnaire asked to the TSOs

### 5.2.1 Context and objectives

*Artelys has been mandated by ACER to carry out a study on the scenario building process leading to the scenarios used in the TYNDP and in the ERAA. The first task we are carrying out is a review of current scenario building process, with a focus on the main scenarios for ERAA (i.e., central reference scenario) and TYNDP (i.e., National Trends +) which are based on NECPs.*

*Given the involvement of your company in the process of scenario building (in particular, the translation of NECPs and national figures into inputs for the TYNDP and ERAA scenarios), we would like you to answer our questions on the current process and the way it could be improved. The questionnaire is expected to take 45mn to complete. [https://artelys778.sharepoint.com/sites/ACER-TYNDPERAA/Documents\\_partages/Project\\_management/Task\\_1\\_-\\_Current\\_processes/2\\_-\\_Questionnaire/Artelys\\_-\\_ACER\\_TYNDP\\_ERAA\\_-\\_Questionnaire\\_to\\_TSOs\\_v9\\_SA.docx\\_-\\_msocom\\_1](https://artelys778.sharepoint.com/sites/ACER-TYNDPERAA/Documents_partages/Project_management/Task_1_-_Current_processes/2_-_Questionnaire/Artelys_-_ACER_TYNDP_ERAA_-_Questionnaire_to_TSOs_v9_SA.docx_-_msocom_1)*

*We kindly ask you to reply by 24<sup>th</sup> March and thank you in advance for your support.*

*The information collected on this form is hosted by Framasoft and processed by Artelys as part of the mission described above. The legal basis for the processing is consent. The raw data collected will be communicated only to members of the Artelys project team mandated to carry out this mission.*

*The raw data is kept for the duration of the mission and will be deleted from the Framasoft hosting service 7 working days after the end of the mission at the request of Artelys. Artelys will keep a copy of this data on its internal servers for a period of 6 months from the end of the mission before proceeding with its deletion.*

You may access your data, correct it, request its deletion or exercise your right to limit its processing. You may withdraw your consent to the processing of your data at any time, you may also object to its processing. You may also exercise your right to the portability of your data.

For more details on Framasoft's hosting conditions, please refer to the [Specific Conditions of Use of Framasoft](#). If you have any question regarding the protection of your personal data or if you wish to exercise your rights you can contact Artelys' Data Protection Officer (DPO) via: [dpo@artelys.com](mailto:dpo@artelys.com)

## 5.2.2 Context on your company

Type	Question	Dest <sup>186</sup>
Op	Name of the company	
Op	Name of the respondent	
Op (optional)	Email address	
MC	Is your company? - Electricity TSO - Gas TSO	
MC+FU	What roles does your company play in the ENTSOs prospective exercise? - Convener - Member of a working group - Involved in modelling - No specific role besides data collection and result validation - Other -> FU, Please specify - I don't know	
Sel	Does your company develop its own scenarios: - For mid-term adequacy assessment? o Yes o No o I don't know - For ten-year and ahead network development plans? o Yes o No o I don't know	
Sel+FU	If your answer above was "Yes", are these scenarios based on the NECPs? - Yes - Partly -> FU, please specify - No - I don't know	
Sel+FU	If your answer above was "Yes", do you rely on these scenarios developed by your company to provide the data requested by ENTSOs?	

<sup>186</sup> Elec: question asked only to Electricity TSOs. Gas: question only asked to Gas TSOs. Blank: question asked to both

	<ul style="list-style-type: none"> <li>- Yes</li> <li>- Partly -&gt; FU, please specify</li> <li>- No</li> <li>- I don't know</li> </ul>	
MC+FU	<p>What roles does your company play in the preparation of the NECPs?</p> <ul style="list-style-type: none"> <li>- NECPs are based on modelling and prospective studies carried out by my company</li> <li>- My company has been consulted for the NECPs elaboration</li> <li>- My company was in charge of developing the NECPs for some sectors</li> <li>- Other -&gt; FU, please specify</li> <li>- I don't know</li> </ul>	

## 5.2.3 Your national NECP

### 5.2.3.1 Time horizon and time-granularity of the NECPs

Sel+FU	<p>What is the time-horizon that your country NECP data covers?</p> <ul style="list-style-type: none"> <li>- Up to 2030</li> <li>- Up to 2035</li> <li>- Up to 2040</li> <li>- Up to 2045</li> <li>- Up to 2050</li> <li>- Up to 2060</li> <li>- Other -&gt; FU, please specify</li> <li>- I don't know</li> </ul>	
MC+FU	<p>How do you derive the data for the years beyond the NECP horizon (e.g. data for 2050 if NECPs stop at 2035)?</p> <ul style="list-style-type: none"> <li>- National long-term strategy submitted to the European Commission</li> <li>- TSOs' own projections</li> <li>- Other -&gt; FU, please specify</li> <li>- I don't know</li> </ul>	
Sel+FU	<p>What is the granularity of data available in the NECPs within the covered time-horizon (e.g. yearly, 5-year span, etc.)?</p> <ul style="list-style-type: none"> <li>- Information available for every intermediate year</li> <li>- Information available every 5 years</li> <li>- No intermediate years available</li> <li>- Other -&gt; FU, please specify</li> <li>- I don't know</li> </ul>	
MC+FU	<p>Within the time frame covered by the NECPs, do you have additional assumptions to provide values to the ENTSOs more time-granular than the data available in the NECPs?</p> <ul style="list-style-type: none"> <li>- Yes, for the demand forecasts</li> <li>- Yes, for the commissioning or decommissioning dates of infrastructure</li> <li>- Yes, for other data -&gt; FU, please precise</li> <li>- No</li> <li>- I don't know</li> </ul>	
Op	<p>If your answer above was "Yes", please specify how (e.g. linear interpolation)?</p>	

### 5.2.3.2 Frequency of publication of NECPs and alignment with ENTSOs data collection timelines

<i>Sel</i>	<p><i>During the previous data collections, were you affected by delays in NECPs publications?</i></p> <ul style="list-style-type: none"> <li>- Yes</li> <li>- No</li> <li>- I don't know</li> </ul>	
<i>Op</i>	<i>If your answer above was "Yes", how did you handle it?</i>	
<i>MC+FU</i>	<p><i>According to the Governance Regulation, Member States are expected to provide NECPs and updated NECPs in alternance every five years. Additionally, Progress reports (NECPRs) should be submitted by Member States to the Commission every two years. For future data collection editions (e.g. TYNDP 2028), on which documents do you intend to rely on to provide revised central scenario estimates to the ENTSOs, as long as no new NECP will have been published since the TYNDP 2026 data collection happened?</i></p> <ul style="list-style-type: none"> <li>- NECPs progress report</li> <li>- Market trends, adjusted to still match unrevised NECP objectives</li> <li>- Revised national strategy (outside of the NECP process)</li> <li>- TSOs' estimates</li> <li>- Other -&gt; FU, please specify</li> <li>- I don't know</li> </ul>	

### 5.2.3.3 Availability of the NECPs data

<i>Sel+FU</i>	<p><i>Are NECPs publicly available in its entirety (including detailed values, values of the graphs presented in the report)?</i></p> <ul style="list-style-type: none"> <li>- Yes</li> <li>- No -&gt; FU, please specify which information or data is missing</li> <li>- I don't know</li> </ul>	
<i>MC+FU</i>	<p><i>If the NECPs are not fully publicly available, how did you proceed to obtain missing data?</i></p> <ul style="list-style-type: none"> <li>- Data obtained from the entity in charge of preparing the NECPs</li> <li>- Data obtained from another entity -&gt; FU, Which one?</li> <li>- Non-publicly available data not obtained in full -&gt; FU, please elaborate</li> <li>- Reverse-engineering carried out to retrieve some data -&gt; FU, please elaborate (e.g. retrieve the installed capacity from the annual generation)</li> <li>- TSOs' own internal scenarios</li> <li>- I don't know</li> </ul>	

### 5.2.3.4 Utilisation of NECPs to provide the data to ENTSOs

<i>MC+FU</i>	<i>To what extent did you rely on your NECP to provide the following datasets requested by ENTSOs (for electricity TSOs, this question applies to both ERAA and TYNDP)?</i>	
--------------	---	--

<b>Annual demand projection</b>					
	<i>Information directly taken from the NECPs</i>	<i>Information partially taken from the NECPs -&gt; FU, please specify</i>	<i>Information not available in the NECPs</i>	<i>Information available in the NECPs but not used to provide the requested data to</i>	

		<i>why and the treatments applied in the box below</i>		<i>ENTSOs -&gt; FU, please specify why and the treatments applied in the box below</i>
<i>Methane</i>				
<i>Hydrogen</i>				
<i>Electricity</i>				
<i>Demand-side response (DSR)</i>				
<i>Other energy carriers -&gt; FU, please specify</i>				

<b>Power system</b>					<i>Elec</i>
	<i>Information directly taken from the NECPs</i>	<i>Information partially taken from the NECPs - &gt; FU, please specify why and the treatments applied in the box below</i>	<i>Information not available in the NECPs</i>	<i>Information available in the NECPs but not used to provide the requested data to ENTSOs -&gt; FU, please specify why and the treatments applied in the box below</i>	
<i>Renewable capacities at the plant level</i>					
<i>Thermal and nuclear capacities at the unit level</i>					
<i>Storage capacities</i>					
<i>Other technical parameters (e.g. yields, must runs)</i>					
<i>Demand-side flexibilities</i>					
<i>Electrolysers installed capacities</i>					

<b>Methane system</b>					<i>Gas</i>
-----------------------	--	--	--	--	------------

	<i>Information directly taken from the NECPs</i>	<i>Information partially taken from the NECPs - &gt; FU, please specify why and the treatments applied in the box below</i>	<i>Information not available in the NECPs</i>	<i>Information available in the NECPs but not used to provide the requested data to ENTSOs -&gt; FU, please specify why and the treatments applied in the box below</i>	
<i>Gas-fired power plants installed capacities</i>					
<i>Biomethane generation forecasts</i>					
<i>Natural gas domestic production forecasts</i>					

<b>Hydrogen system</b>					<b>Gas</b>
	<i>Information directly taken from the NECPs</i>	<i>Information partially taken from the NECPs - &gt; FU, please specify why and the treatments applied in the box below</i>	<i>Information not available in the NECPs</i>	<i>Information available in the NECPs but not used to provide the requested data to ENTSOs -&gt; FU, please specify why and the treatments applied in the box below</i>	
<i>Electrolysers installed capacities</i>					
<i>SMR installed capacities</i>					
<i>Infrastructure levels (e.g. pipelines and storages)</i>					

<i>Sel+FU</i>	<p><i>If one or more of the inputs, listed in the template above, do not come from your national NECP, did you rely on third parties to fill the gaps and provide part of the required datasets to the ENTSOs?</i></p> <ul style="list-style-type: none"> <li>- <i>Yes -&gt; FU, if so, please specify what type of third parties (ministries, academia, consultants, etc.)</i></li> </ul>	
---------------	--	--

	<ul style="list-style-type: none"> <li>- No</li> <li>- I don't know</li> </ul>	
--	--	--

### 5.2.3.5 Deviations from the NECPs

Sel+FU	<p>Do you deviate from any information available in your national NECP when providing the required datasets to the ENTSOs?</p> <ul style="list-style-type: none"> <li>- Yes -&gt; FU, please specify for which data (e.g. demand projections, RES infrastructure level projections) and why (e.g. NECPs are too old, change of political priorities, market uptake in the NECPs is deemed to be too quick or too slow, etc.)?</li> <li>- No</li> <li>- I don't know</li> </ul>	
Sel	<p>In case of deviations, do you inform the ENTSOs?</p> <ul style="list-style-type: none"> <li>- Yes</li> <li>- No</li> <li>- I don't know</li> </ul>	
Sel	<p>In case of deviations, do you need to provide a justification to the ENTSOs?</p> <ul style="list-style-type: none"> <li>- Yes</li> <li>- No</li> <li>- I don't know</li> </ul>	
Sel+FU	<p>Is the electricity grid assumed in the TYNDP and ERAA scenarios consistent with the NECPs?</p> <ul style="list-style-type: none"> <li>- Yes, for both TYNDP and ERAA</li> <li>- Partly -&gt; FU, please elaborate</li> <li>- No, the alignment has not been checked</li> <li>- The NECPs does not provide sufficiently detailed data to answer this question</li> <li>- Other -&gt; FU, please specify</li> <li>- I don't know</li> </ul>	Elec
Sel+FU	<p>Is the hydrogen grid assumed in the TYNDP scenarios consistent with the NECPs?</p> <ul style="list-style-type: none"> <li>- Yes</li> <li>- Partly -&gt; FU, please elaborate</li> <li>- No, the alignment has not been checked</li> <li>- The NECPs does not provide sufficiently detailed data to answer this question</li> <li>- Other -&gt; FU, please specify</li> <li>- I don't know</li> </ul>	Gas

### 5.2.3.6 Other questions related to data preparation by your company

Sel+FU	<p>Are the same people/departments involved in the data collection for ERAA and TYNDP scenarios?</p> <ul style="list-style-type: none"> <li>- Yes</li> <li>- No -&gt; FU, if not, do these people/departments coordinate regularly to ensure consistent data where relevant?</li> <li>- I don't know</li> </ul>	Elec
Sel+FU	<p>In some situations, do you provide different values for TYDNP and ERAA?</p>	Elec

	<ul style="list-style-type: none"> <li>- Yes -&gt; FU, if so, please specify for which data and why</li> <li>- No</li> <li>- I don't know</li> </ul>	
--	--	--

### 5.2.4 Inputs validation

<i>Sel+FU</i>	<p>Before submitting to ENTSOs, do you carry out some verifications about the data provided (e.g. consistency checks, comparison with previously provided values, comparison with national plans)?</p> <ul style="list-style-type: none"> <li>- Yes -&gt; FU, If so which ones?</li> <li>- No</li> <li>- I don't know</li> </ul>	
<i>MC+FU</i>	<p>Before submitting to ENTSOs, do you validate the data with:</p> <ul style="list-style-type: none"> <li>o NRAs</li> <li>o Other national authorities -&gt; FU, please, specify.</li> <li>o Other stakeholders (e.g. through dedicate stakeholder engagement or other national processes if the same data is used for other national exercises) -&gt; FU, please, specify</li> <li>o I don't know</li> </ul>	
<i>Sel</i>	<p>Do you align with other national TSOs, within your country or with teams in charge of the other energy carriers (if your company covers both electricity and gas) before submitting data to ENTSOs?</p> <ul style="list-style-type: none"> <li>- Yes, with other TSOs</li> <li>- Yes, with other teams within my company</li> <li>- No</li> <li>- I don't know</li> </ul>	
<i>Op</i>	<p>If your answer above was "Yes", how is the alignment ensured, both on the short (up to 2030) and long-term horizons (2050)? How do handle different visions of the future between concerned TSOs?</p>	
<i>Op</i>	<p>If your answer above was "Yes", are there data or horizons for which alignment with other TSOs is more difficult than others? Are there any differences in the alignment process between the different horizons?</p>	
<i>MC+FU</i>	<p>In the data collection process, do you coordinate with TSOs from neighbouring countries?</p> <ul style="list-style-type: none"> <li>- Yes, for the interconnection capacities</li> <li>- Yes, for other data -&gt; FU, please specify</li> <li>- No</li> <li>- I don't know</li> </ul>	
<i>Op</i>	<p>If your answer above was "Yes", could you describe the process followed, especially in case of different visions between the countries (e.g. inconsistent NECPs, or differences in the TSOs views)?</p>	
<i>Sel+FU</i>	<p>Did you iterate with ENTSOs during the data collection process?</p> <ul style="list-style-type: none"> <li>- Yes -&gt; FU, please specify on which data and aspects</li> <li>- No</li> <li>- I don't know</li> </ul>	

### 5.2.5 Scenario results validation

<i>Sel</i>	<p>Have you noticed deviations between the data you have provided to the ENTSOs and the values published by the ENTSOs?</p> <ul style="list-style-type: none"> <li>- Yes</li> <li>- No</li> <li>- We have not checked the values</li> <li>- I don't know</li> </ul>	
<i>Sel+FU</i>	<p>If you notice any inconsistencies in scenario input data, are there any mechanisms (e.g. loopback channels, etc.) that enable you to pass on the ones you detected to the ENTSOs?</p> <ul style="list-style-type: none"> <li>- Yes -&gt; FU, please specify</li> <li>- No</li> <li>- I don't know</li> </ul>	

### 5.2.6 Recommendations

<i>Op</i>	<p>Would you suggest any other improvements of the process to establish the set of assumptions of central scenarios of TYNDP and ERAA?</p>	<i>Elec</i>
<i>Op</i>	<p>Would you suggest any other improvements of the process to establish the set of assumptions of central scenarios of TYNDP?</p>	<i>Gas</i>

## 5.3 Answers collected to the questionnaire sent to the national TSOs

Country	Company	Electricity TSO	Gas TSO
AT	AGGM Austrian Gas Grid Management AG		1
	APG	1	
	Gas Connect Austria		1
	TAG GmbHŞ		1
BE	Elia	1	
CZ	ČEPS, a.s.	1	
	NET4GAS		1
DE	ONTRAS Gastransport GmbH (on behalf of the German Gas TSOs)		1
DK	Energinet	1	1
ES	ENAGAS S.A.		1
	Red Eléctrica	1	
FI	Gasgrid Finland Oy		1
FR	NaTran		1
GR	DESFA S.A.		1
HU	MAVIR Ltd.	1	
IE	EirGrid	1	
IT	Snam Spa		1
	TERNA	1	
LT	AB Amber Grid		1
	LITGRID AB	1	
LU	Creos Luxembourg S.A.	1	
LV	AS Augstsprieguma tikls	1	
NL	Gasunie		1
	TenneT	1	
PT	REN	1	1
SE	Svenska kraftnät	1	
SK	SEPS	1	
<b>Total</b>		<b>15</b>	<b>14</b>